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THE

AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES

EDITORS AND PROPRIETORS

PROF. SAMUEL CALVIN, *University of Iowa, Iowa City, Iowa.*
PROF. EDWARD W. CLAYPOLE, *Buchtel College, Akron, O.*
DR. PERSIFOR FRAZER, *Franklin Institute, Philadelphia, Penn.*
DR. LEWIS E. HICKS, *University of Nebraska, Lincoln, Neb.*
MR. EDWARD O. ULRICH, *Geol. Survey of Illinois, Newport, Ky.*
DR. ALEXANDER WINCHELL, *University of Michigan, Ann Arbor, Mich.*
PROF. NEWTON H. WINCHELL, *University of Minnesota, Minneapolis, Minn.*

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ERRATA.

On page 40, 14th line from bottom, for hopeful read helpful.
" 56, 8th " " for illusion read allusion.
" 64, 2nd " top, for when read then.
" 176, 15th " bottom, for thickens read thickness.
" 219, last line, for northwest read newest.

THE

AMERICAN GEOLOGIST

VOL. I. JANUARY, 1888. NO. I.

INTRODUCTORY.

The starting of a new scientific journal is a step which should be accompanied by a statement of the reasons and purposes which have actuated its originators. These reasons and purposes should form the platform of principles, and the arena of action which should characterize the publication.

The science of geology is comprehensive, and depends for its progress on the special researches of laborers in all the natural sciences. The editors of THE AMERICAN GEOLOGIST have lamented from time to time the lack of a distinctively geological journal in the United States, whose purpose should be to coördinate and express the results of these special labors on the general science of geology, and which should serve as a repository of the progressive steps which the science, as such, makes from year to year. They have lamented the absence of a journal which should take cognizance of the various laboratories of the world, and of the publications that emanate from the various scientific centers, and, culling from them all such facts and discussions as throw light on the *history and constitution of the globe*, should authentically eliminate for its subscribers the essential grand results, freed from the distractions of too much detail. These results, mingled with a confusion of unsystematized details, are now scattered through journals and special publications which are devoted to the special sciences, and are inaccessible and unavailable to the geologist without the expenditure of much time and money.

The promoters of THE AMERICAN GEOLOGIST have witnessed a growing popular appreciation of the grand truths of

geology, and of the utility of a knowledge of its methods and results. In all the colleges of the country, which deserve the name, nay, in many of the high-schools and academics as well as in schools of lower grade, will now be found frequently a curriculum of study which specially provides for the teaching of geology in some form or another. Even in the primary schools, the pupil is told to bring pebbles from the roadside to the school-room to serve as texts for object lessons by the teacher. At the same time there is a demand for a knowledge of the ways and means of geological information. Qualified teachers and enthusiastic professors of natural science are not the only necessity. There should be a reservoir of observations and of information contributed by the expert workers of the world from which teachers may draw new facts and new ways of combining them. The ways and means of scientific instruction need to be made known to ten-thousand earnest teachers who have only the recollection of their own college training to guide them, if indeed they have had any training at all, and who are shut off from access to the technical publications of the specialist.

More than all a thoroughly non-partisan publication is needed which shall be open to the properly worded opinions of all from the most powerful to the most obscure, and which is distinctively committed to no theory whether of construction or of obstruction. It will be the aim of this journal to reflect the faintest whispers as well as the loudest thunder of American geological thought.

The promoters of THE AMERICAN GEOLOGIST have been satisfied for several years past that the interests of the science of geology in America have been jeopardized, and sometimes have suffered, because of the lack of coöperation among American geologists, and of a ready means of expression through a sympathetic medium of communication.

Many of them have had serious misgivings as to the result of the influence of the national geological survey in extending its operations into the settled states of the Union, and especially into states in which official geological surveys are in progress, fearing that by the concentration of all authority and control at the national capital, and by the extensive accumulation at one centre of all

the material illustrating the state and local geology of the country, the local interest and effort may die out, and that ultimately the weight of public sentiment favorable to geologic investigation may suffer diminution. Such a result, besides retarding the general advance of geologic interests, would inevitably react on the national survey itself. It is hoped by the promoters of THE AMERICAN GEOLOGIST that its influence may serve to perpetuate the general interest in geological investigation, and that with this view, the numerous workers on the national survey may lend the enterprise their countenance and support. The editors of this journal pledge to them and to all geologists of whatever school or party, that THE AMERICAN GEOLOGIST shall be conducted on a plane of judicial impartiality, above the influence of factions and of personal or local controversy. The existence of an avenue through which the local interests of geology throughout the country may find expression, and through which the contributions to science that emanate from the laboratories and libraries of numerous students, may be laid before their fellow workers, will serve as a stimulus to local investigation, promote the interests of general intelligence and strengthen that basis of popular appreciation on which every public scientific enterprise--state or national —ultimately rests.

A SHORT HISTORY OF THE ORIGIN AND ACTS OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS, AND OF THE AMERICAN COMMITTEE DELEGATES TO IT.

BY PERSIFOR FRAZER.

ORIGIN OF THE COMMITTEE.

At the Buffalo meeting of the A. A. A. S. (of 1876) the Standing Committee of the association offered to the genera. session the following:

RESOLVED, that a committee of the association be appointed to consider the propriety of holding an international congress of geologists at Paris during the international exhibition of 1878, for the purpose of getting together comparative collections, maps, and sections and for the settling

of many obscure points relating to geological classification and nomenclature. etc., etc.

The other clauses relate to the appointment of Torrell and Baumhauer, and others, to assist the committee, which latter was composed of W. B. Rogers, James Hall, J. W. Dawson, J. S. Newberry, T. S. Hunt, C. H. Hitchcock and R. Pumpelly, [Executive proceedings, A. A. A. S. Buffalo meeting, 1876].

PREPARATIONS FOR THE CONGRESS.

At the Nashville meeting, in 1877, the Standing Committee recommended that Prof. J. P. Lesley and And. C. Ramsay be added to the international geological committee. Dr. Hunt presented a report of the committee in executive session, and on recommendation of the Standing Committee, in addition to the above two names, the presidents of the Geological Societies of France, London, Edinburgh, Dublin, Berlin, Belgium, Italy, Spain, Portugal, and of the Imperial Geological Institute of Vienna, were added [Nashville volume, A. A. A. S., Exec. Proc.]

At the Saratoga meeting, August, 1879, Prof. James Hall, chairman of the American committee, made a report of the proceedings of the first International Geological Congress in Paris, held August 29, 1878, from which the following is extracted:

There were present at the Congress Profs. Lesley, Hunt, Hall, Cook, Blake, Cope, Chamberlin and Selwyn.

At the Congress at Bologna, to be held Aug. 29th 1881, there are two principal subjects comprised under two groups, and for each of these an international committee was named at Paris. 1st, Unification of geological cartography. 2nd, Unification of geological nomenclature, under which head will be considered all matters relating to classification as well as to the value and significance of mineralogical, lithological and paleontological characters, thus embracing many of the most important problems of geology. In naming these, as far as possible one member from each country was appointed, whose duty it is to organize therein separate local committee for each group, and to communicate to the secretary of the Council of the Paris Congress, and with the local committees at Bologna. For the committee on the map the American members were Lesley (U. S.), Selwyn (Can.). On geological nomenclature, Hall, (U. S.), and Hunt (Can.). In view of the fact that the work of the International Geological Congress was initiated by the American Association for the Advancement of Science, and that it promises to become one of permanent and increasing importance, it is believed that it will be for the best interests of geological science that the committee be continued etc.,

and further that its scope may, with advantage, be extended to include the consideration of such questions relating to state and national geological surveys as may from time to time arise.

On motion of major Powell the report was accepted and the recommendation adopted.

The foreign members were dropped from the American committee.

At a subsequent meeting of the committee, held at Saratoga, Sept. 1, 1879, the names of Geo. H. Cook, James D. Dana and Clarence King, were added to the committee; the other members being James Hall, W. B. Rogers, J. W. Dawson, J. S. Newberry, C. H. Hitchcock, R. Pumpelly, J. P. Lesley and T. Sterry Hunt.

At the Boston meeting in 1880, in the executive proceedings, the committee on the International Congress of Geologists was discharged. [See the report in the proceedings.]

In the proceedings of the American Association for 1880 and 1881 no mention of the committee is made, and it does not appear among the standing committees of the association in the reports of the Boston and Cincinnati meetings for those years.

At the Montreal meeting, in 1882, Dr. Hunt stated, in behalf of the International Geological Committee, of which Hall, Selwyn, Lesley and himself had been appointed representatives of North America by the Congress at Paris, that a report had been prepared some months ago, and asked that the committee be continued, which was done, Prof. Hall seconding the motion. No mention is made in the volume of the proceedings of the Bologna Congress.

At the Minneapolis meeting, 1883, the committee on the International Congress of Geologists was continued. At this time, and the year before, when it was resuscitated, it consisted of Hall, Dawson, Newberry, Hunt, Hitchcock, Pumpelly, Lesley.

In 1884 Powell, Cook, Stevenson, Cope, and Smith were added by the General Session on recommendation of the Council, and the committee was continued.

In 1884, Frazer, H. S. Williams and N. H. Winchell were added. In this year there were present at the Berlin Congress, of the above as delegates, Hall, Newberry, Williams and Frazer. Prof. Brush, being in Berlin at the time, and a member of the

Congress already, was invited to act with the American committee during the session.

The secretary of the American committee took notes of the proceedings of the Congress and prepared an account which appeared in the American Journal of Science for December, 1885. This account was forwarded to all the principal participants in the debates, and with a few corrections furnished by these, and on the expressed opinion of M. Fontannes, the official secretary of the Congress, who had all the notes and edited the proceedings of the Congress, that it was "rigorously exact," a pamphlet was issued at the expense of the committee, 300 copies of the provisional color scale printed at Berlin having been imported and added to it.

Meetings of the American committee have been held twice in New York city, once in Philadelphia, once in Albany, once at Spring Lake, New Jersey, and again in New York city, at Columbia College, during the session of the American Association for the Advancement of Science. Reference will be made to the proceedings of these meetings in another place.

Short History of the Proceedings of the various Congresses—the Paris Congress.

The program of the Congress, as given in the front of the volume of its proceedings [Paris session, 1878], is seen to be:

1. Unification of geological works in respect of nomenclature and symbolic representation.

2. Discussion of various questions concerning the limitations and characteristics of certain terranes.

3. Representation and co-ordination of the facts of alignment (faults and veins).

4. Respective value of faunas and floras, from the point of view of the boundaries of terranes.

5. Value of mineralogical composition and texture of the rocks, from the point of view of their origin and their age.

On Thursday, August 29th 1878, at 3:15 P. M., in the palace of the Trocadero, in Paris, the first Congress was opened under the presidency of the Minister of public instruction. M. Hébert, the president of the committee of organization, made the opening address, and almost immediately stated the principles

which must govern a Congress of this kind, and which have faithfully been carried out in all subsequent meetings. If the gentlemen who noisily and quasi-officially apply the worldly definition of orthodoxy and heterodoxy to their plans and other people's plans of reforming the science, would but read what has been done, they would be spared the labor of killing a great many corpses, and of inventing a great many old proverbs. The first Congress was hardly five minutes old when M. Hébert remarked: "Pour atteindre notre but, nous aurons certainement a surmonter des grands obstacles, de nombreuses difficultés, et ces difficultés ne sont pas toutes de nature a être levées par un Congrès. On ne saurait ici invoquer la loi du nombre; nulle majorité ne saurait imposer des convictions que le sentiment du vrai peut seul amener. Cependant, de l'échange des idées, de la discussion des faits et des opinions, résultera necessairement, pour les amis de la verité, une salutaire influence; et des réformes spontanées pourront être la conséquence de nos réunions." etc.

This wise and just langauge has been the key-note of all future acts of the Congress; and until one can point to some act which has the appearance of abandoning the policy here indicated, the implication of the members of any particular session in the attempt to usurp authority is most unjust.

The position of the American committee toward the Congress is somewhat peculiar, and was alluded to in the remarks of M. Janettaz on the occasion just mentioned. After sketching the birth and progress of the idea of an international congress in accordance with the facts given above, he says (speaking of the savants of all nations who were assembled in Philadelphia) "Ils créèrent, en conséquence, un comité auquel nous avons donné en France la dénomination de Comité fondateur de Philadelphie, pour rapeller a la fois son initiative et l'exposition de la noble cité Americaine, qui en avait eté le point de départ."

The story of the creation of the Congress then, as told by its official publications, is this: A number of savants representing the larger number of civilized countries, who were in the United States in 1876 for the purpose of visiting the Centennial Exposition, named a committee to inaugurate the project. Of this committee professor James Hall was president and Dr. T. Sterry

Hunt was secretary. The committee announced to all scientific societies of the world the proposed inception of the plan during the French Exposition of 1878, and appealed to M. Tournouër, then the president of the Geological Society of France, for assistance. The Council of the society was made a committee of organization, in conjunction with the members of the Institute of France in the section devoted to matters akin to those about to engage the attention of the Congress,—including in these zoology and botany, and the professors of natural history chairs in Paris. [See vol. i, Proceedings of the International Congress, p. 27.]

The first question submitted by the committee on organization for discussion by the Congress, was the unification of the nomenclature and the conventional symbols used in geology. The second was the boundaries between the terranes. The third relates to the works published on the alignment of dykes, and in part to experimental geology. The fourth (the respective value of faunas and floras in the determination of the boundaries of terranes) comprised the actual problems of paleontology. The fifth (the value of the mineralogical composition and of the texture of rocks, from the point of view of their origin and their age) was suggested by the success of the application of the microscope, and of the principles of optical science, to lithological questions.

A provisional bureau was named by the Council of the Congress which issued a series of rules applicable to the Paris session.

These rules comprise the following parts: Article I. The first Congress, assembled by the committee of founders of Phila delphia and the committee of organization of Paris, will meet in Paris from August 29 to September 4, 1878. (Art. II,) in the Palace of the Trocadero at 3 P. M. Art. III. The payment of 12 francs entitles the delegate to attend the sittings, to take part in the discussions and votes, and to receive the volume of the Proceedings of the Congress. Art. IV. The direction of its labors confided to a Bureau and a Council. Art. V. The Council shall be composed of, 1st, the members of the committee of founders; 2nd, the members of the committee of organization; 3rd, the members of the Bureau of the Congress; 4th, the exis-

ting presidents of the French or foreign geological societies, and the directors of large geological surveys; 5th, the members of the Congress that the Council may call to sit with it. It will assemble in the halls of the Geological Society of France. Art. VI. The Bureau will be elected at the first session of the Congress from a list of proposals made by the Council. It will be charged with the duty of arranging the program for each day.

Art. VII. On account of the number of communications announced none shall be longer than a quarter of an hour except by permisssion of the Bureau.

Art. VIII. Communications which shall be made in English or German, but of which the authors shall have handed in a written copy in advance, will be immediately analyzed in French by the Bureau.

Art. IX, X, XI, refer to privileges which were secured for the members of the Congress on presentation of their tickets at various institutions and museums in Paris during and after the session of the Congress. On August 30, Prof. Lesley was elected vice president of the Congress, representing the United States.

The Bureau of the Paris Congress consisted of Hébert (France), president; Davidson (England); Liversidge (Australia); de Koninck (Belgium); T. Sterry Hunt (Canada); Johnstrupp (Denmark); Vilanova (Spain); Jas. Hall, J. P. Lesley (United States); Daubrée (France); Szabo (Hungary); Capellini (Italy); de Baumhauer (Holland); Ribeiro (Portugal); Stéfanescu (Roumania); de Moeller (Russia); Torrell (Sweden and Norway); Favre (Switzerland); Janettaz (France), general secretary.

A large part of the time at the Congress was taken up with lectures on various subjects of science by Daubrée, Michel, Levy, Favre, Lory, Chancourtois, de Lapparent, Chas. Barrois, James Hall, Renevier, Stéfanescu, Rutot, Vilanova, T. S. Hunt, Barrande, Hébert, de Moeller, Gosselet, Lesley, Velain, Malaise, Cope, Rouault, Mortillet, Winkler, Vanden Broeck, Blake, Choffat, Ribeiro, des Cloizeaux, Selwyn, Virlet d'Aoust, Delesse, Chamberlin, and some others. When it is stated that many of them lectured two and three and even four times, and

that the session of Congress only lasted one week, some idea may be formed of the rapidity with which the true business of the Congress was disposed of. This very natural license was followed at Bologna, and in less degree in Berlin, but still, even in this last session enough to cause a great many matters of detail which might have been finally disposed of, to go over three years for settlement. It is very natural that the eminent apostles of research who attend these Congresses should wish to bring before their fellows the latest results at which they have arrived and that the great body of members should wish to hear them, but then excursions to the boundaries of the picket lines of science should first be relegated to extra hours, and secondly they should be few enough to enable all possible business which cannot be settled through the media of scientific publications, to occupy every precious minute of the time when the members are together, for the reunion is costly and difficult.

On the last day of the session it was decided, 1st, to hold the next Congress in 1881; 2nd, at Bologna, 3rd, about the beginning of October, 4th, with Sella as honorary president, and 5th, with a committee of organization of Capellini president, Gastaldi, Gemmellaro, Giordano, Guiscardi, Meneghini, Omboni, de Pirona, Ponzi, Taramelli.

Two international committees were appointed. That on unification of geological cartography — figurés géologiques — consisted of Liversidge, Dupont, Selwyn, Ribeiro, Lesley, de Chancourtois, de Hantken, Giordano, de Moeller, Torrell, Renevier; that on unification of geological nonenclature, of Liversidge, Dewalque, T. Sterry Hunt, Vilanova, James Hall, Hébert, Szabo, Capellini, Stéfanescu, Inostranzeff, Lundgreen, Favre.

It was decided that the committees should complete their numbers in the cases of countries not represented, death, or resignation, by a two-thirds vote. Also that each member of the international committee should institute a local committee of which he should communicate the constitution to the corresponding international committee.

The wish of the Congress was expressed that in the formation of the local committees the principal geological societies of each country should be consulted.

The committees were to organize as soon as possible and to

communicate their organization to the present (Paris) Congress and to the committee of organization of the next (Bologna).

Their reports were to be sent before the 1st of Jan., 1881, to the committee of organization of the Bologna Congress which should be responsible for having them printed before the opening of that Congress.

Committees were appointed to study the questions of rules to be followed in establishing the nomenclature of species. These committees were to consist, for paleontology, of Cotteau, Donvillé, Gaudry, Gosselet, Pomel, de Saporta, and for mineralogy of Des Cloizeaux, and Janettaz. After the usual amount of the commodity designated by the English A. A. S. "butter," the Congress adjouned.

(To be concluded.)

THE ANIMIKE BLACK SLATES AND QUARTZYTES, AND THE OGISHKE CONGLOMERATE OF MINNESOTA, THE EQUIVALENT OF THE "ORIGINAL HURONIAN."

BY N. H. WINCHELL.

The existence or not of a stratigraphic rock-horizon which could be denominated *Huronian* has been debated by geologists. The true character of the rocks of which the Huronian is composed has been misunderstood. They have been described as "greenstones," in general terms, and no designation could be further from the truth. So long as this idea of the composition of the Huronian prevails, doubt and disagreement will continue. The confusion that has arisen respecting the Huronian is due, to a large extent, to the contradictory and variant descriptions published by the authors of that name, *that is,* the geologists of the Canadian geological survey. Mr. Murray referred to the rocks on the north shore of lake Huron in some of the earlier reports of that survey, and so far as I have observed he had definite and correct ideas of their nature. The name, and the first announcement of it, were accredited to Messrs Logan and Hunt jointly. Mr. Hunt, who has written largely of the Huronian, took his conception of its nature from samples which had been gathered by others, never having visited the locality

himself, so far as I have been able to learn; while Mr. Logan, who studied it later on the shores of lake Superior where the rocks that Mr. Murray described on the north shore of lake Huron appear on the lake Superior shore, amplified the formation by adding some strata, or some phases of the strata, that are not mentioned by Mr. Murray. Later still, following the definition of the *horizon* which it was supposed the Huronian occupies, Mr. Bell and Mr. Dawson, as well as nearly all American geologists, have swept under the same designation several lower, and quite distinct, stratigraphic terranes. This confusion was intensified by the application of another name to a group of rocks in northern Minnesota and the adjacent parts of Canada, by Dr. Hunt, which it is the object of this paper to show is the *same as the principal member of the Huronian* in the original area of Murray, on the north shore of lake Huron. This new name, the "Animike slates and quartzytes," was thought by Dr. Hunt, to cover a series of strata much later than the Huronian; and even later than the copper-bearing rocks of lake Superior. They have been found, however, to run below the copper-bearing rocks, and to constitute a great formation whose extent in Minnesota has been found to be at least a hundred and twenty-five miles, and whose equivalents in Michigan and Wisconsin are gradually being identified.

Mr. Irving, who has examined the area of the original Huronian within the last two years, has called attention to the nature of the strata of which it is composed. His general description is the same that I should give, with the exception that I should not apply the term *graywacke*, to any of the rocks there found. The graywackes, so far as I am acquainted with them, appear in the Marquette and Vermilion iron regions, and probably in a lower formation; the strata to which Mr. Irving seems to have applied this term are quite different from the graywackes seen in the iron-bearing rocks at Vermilion. Instead of being coarsely granular, largely made up of feldspathic material and of a gray color, the beds of the Huronian are mainly siliceous, fine-grained and of a rather firm texture. They are interbedded with, and pass into, fine-grained carbonaceous slates. They are better described taken altogether, as *black slates and quartzytes*.

But the original Huronian embraces, not only these black slates and quartzytes, which in their lower portions become the "slate conglomerate" of the region, but also, overlying the slates and quartzytes, a great quartzyte of a different kind. This overlying quartzyte constitutes perhaps the most conspicuous member of the original Huronian. Its thickness is very great, reaching perhaps ten thousand feet. It is red in its lower half, and nearly white in its upper. Both parts become pebbly, and even coarsely conglomeritic in limited and local areas. There is probably no stratigraphic or physical break between these parts, but while on the ground during the month of July, 1887, it became convenient to distinguish these parts by different names. The lower red portion was named *Thessalon quartzyte,* and the upper white, was named *Otter Tail quartzyte.* These quartzytes are composed almost entirely of silica. The original rounded grains are everywhere distinct as individual, fragmental ingredients, but the rock is so compacted together, and perhaps cemented by "interstitial silica," that no intergranular spaces are empty.

No one who has seen this quartzyte, and the quartzytes of central Wisconsin and Minnesota which have been distinguished by local geographic names,—Barraboo quartzyte, Sioux quartzyte, and Barron County quartzyte,—could fail to note at once the similarity of lithologic and all outward characters which this Huronian quartzyte bears to them. This is so great that the observer begins at once to seek for other parallels. He finds these in the tilted condition of the strata, in the associated red felsytes, in the eruptive intrusions of diabasic rock and the apparent general parallelism of geological horizon. It is true the red quartzytes of central Wisconsin and Minnesota have not been proven yet to overlie a series of black slates and quartzytes, but in the northern Minnesota the Animike black slates and quartzytes are known to underlie a great thickness of reddish and gray quartzytes which have been considered the northern equivalent of the quartzytes of central and southern Minnesota.

Indeed the identity of this Huronian quartzyte with these more southern quartzytes is so strongly impressed on the observer that he is compelled at once to assume an identity of age, regardless of the late dogma that lithologic characters are of lit-

tle or no value in determining rock horizons; and it becomes almost a matter of surprise to him that this identity has not before been shown by those familiar with the original Huronian.

The parallelisms which I consider established, or highly probable, can be tabulated as follows:

	Minnesota.	*Wisconsin.*	*Original Huronian.*
1	Sioux Quartzyte and Catlinite beds.	Barraboo Quartzyte.	Otter Tail Quartzyte.
	New Ulm Quartzyte.	Barron Co. Quartzyte.	Thessalon Quartzyte.
	Wauswaugoning bay Quartzytes.	(Felsytes of central Wisconsin?)	(The upper quartzytes of the region.)
2	Animike slates and Quartzytes. The Gunflint Beds.	Rocks of the Gogebic range.	The Upper black slate.
3	Ogishke Conglomerate.	The modified conglomerate south of the Gogebic range, (the granite.)	The Lower slate conglomerate.

No attempt will be made here to find parallels of these formations in other parts of the country. It is suffcient to call attention to the discovery of fossils of primordial character, or perhaps pre-primordial, in the Catlinite beds of south-western Minnesota, and hence to the necessity of removing the Huronian from the Archæan.

THE UNCONFORMITIES OF THE ANIMIKE IN MINNESOTA.[1]

BY A. WINCHELL.

"Animike" is a term employed to designate an assemblage of strata occupying a position between the Copper-bearing, Nipigon, or Kewenian series of lake Superior and the great gneissic and granitic base commonly designated Laurentian. The precise stratigraphical position and equivalences of the assemblage are not yet settled by common consent; and it is the

[1] The observations here recorded were made during a connection with the work of the Minnesota geological survey, and are published with the sanction of the state geologist. Full details will be given in the sixteenth annual report of the survey.

purpose of this paper to contribute a few facts suited to throw light on the question.

The Animike formation covers an extensive area stretching from Thunder bay of the north shore of lake Superior, southwestward as far as Duluth, and still beyond to the Mississippi river. The lake-shore belt, however, from Grand Portage, for an average width of about twenty miles, is occupied by rocks of the Kewenian series. The Animike rocks for the greater part, are evenly and thinly laminated, and have a southerly dip along the international boundary of about five to ten degrees. They embrace a great thickness of black carbonaceous argillytes, varying to pure slaty argillytes, black magnetitic slates, often rich in iron, and siliceous schists sometimes quite purely siliceous and ranging in color to chalcedonic, flinty, cherty and red-jaspery. The magnetitic horizon presents, over an extensive area west of Gunflint lake, on the boundary, remarkable deposits of valuable ore ranging from lean to nearly pure magnetite. At a lower horizon are beds of ferruginous (perhaps sideritic) dolomite, and compact sandstone holding a considerable percentage of fine granular orthoclase. The territory of the formation is characterized by high precipitous bluffs facing northward, but sometimes westward, and generally capped by a thick table of gabbro, which, on the eroded side, presents rude columnar aspects.[1]

Sir William Logan regarded the formation as the "Lower Group" of the copper-bearing series. Mr. Bell in his reports of 1866-9 and 1872-3, expresses the same view. Macfarlane,[2] on the contrary, described it as newer than the copper-bearing series. Dr. T. S. Hunt, also, who was the first to propose the name "Animike," (from the Chippewa for "thunder")[3] at first considered the formation as lying above the copper-bearing

[1] Full descriptions of the formation may be found in Logan's Geology of Canada, 1863, pp. 66-70, and more extended, in Irving's Copper-bearing Rocks of lake Superior. Monographs of the United States geological survey, vol. v, pp. 367-386; also Third annual report of U. S. Geol. Survey, pp. 157-163. The reader may consult also, Bell, in Geol. Surv. of Canada, Report for 1866-1869, pp. 318-19, and Rep. 1872-3, pp. 92-3.

[2] Canadian Naturalist, New Series, iii, 252; iv, 38.

[3] Hunt, Trans. Am. Inst. Mining Engineers, vol. i, p. 339.

rocks; but in 1883 he announced the opinion that their place is below.[1] N. H. Winchell, in 1880, considered the Animike "to be only a downward extension of the Cupriferous Series."[2] The inferior position of the Animike has also been maintained by Irving[3] in various publications. But he does not regard it as the lower part of the Kewenian.[4] He holds it to be an older system of series separated from the Kewenian by a long interval of erosion, if not by an unconformity. He holds it to be the equivalent of the typical Huronian of Canada, north of lake Huron. But he also parallelizes it with the iron-bearing schists of the Marquette, Menominee, Gogebic and Vermilion regions. After a general survey of the rocks of the various regions, he concludes: "It thus appears that the Marquette and Menominee iron-bearing schists are essentially the same lithologically, with those of the Animike group of the north shore."[5] And again: "The original Huronian, the Animike slates, the Penokee iron-rocks and the iron-bearing rocks of the Marquette and Menominee regions, appear to me, then, in all probability, to belong together, and I may hence properly call them all Huronian."[6] Again, speaking of the rocks in northeastern Minnesota assembled by Bell in the Huronian, professor Irving expresses a doubt whether the mica-schists and hornblende-schists are not rather dependencies of the older gneisses; but in reference to the whole Huronian assemblage of Bell, he concludes: "In the present state of our knowledge, it seems probable enough that a large part of them should be so referred."[7] He recognizes the difficulty presented in the attempt to make the flat-

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[1] Hunt, The Taconic System in Geology, Trans. Roy. Soc. Canada, vol. I, sec. iv, p. 250.

[2] N. H. Winchell, Ninth Ann. Rep. Geol. Surv. Minn., p. 70.

[3] Irving, Third Ann. Rep. U. S. Geol. Surv., pp. 157-163; Monographs U. S. Geol. Surv., vol. v, (1883) pp. 367-386, 395; Preliminary Paper on an investigation of the Archæan formations of the Northwestern States, March, 1886, extracted from sixth Ann. Rep. U. S. Geol. Surv., 203-205.

[4] This form of the term is preferred to "Kewenawan," both because more euphonious and of earlier introduction. We are indebted to Hunt also, for this designation. It is, however, a synonym of "Nipigon."

[5] Monographs, vol. v, p. 394.

[6] Monographs, vol. v, p. 395.

[7] Monographs, vol. v, p. 206.

lying Animike rocks the equivalent of the perpendicular clastic slates of the Vermilion lake iron-bearing schists; but he attempts to remove the difficulty by stating that broad gneissic and granitic masses everywhere intervene between the areas of the two sorts of schists, and reminding us of the possibility that the upheaval of them might leave the strata on one side at no great distance from the upheaval, still in a horizontal position, while those on the opposite side may have been tilted to verticality. It is useless to discuss the correctness of the principle, since it now appears that the Animike slates and the Vermilion slates are not always separated as supposed. I cannot occupy the space in the present article requisite to prove this position; since, after explaining to the general reader what the Animike series is, it is my sole object to point out some interesting examples of its unconformity with older rocks.

The vertical earthy schists which embrace the vast hæmatitic deposits of Vermilion lake, in northern Minnesota, are traceable, without any important discontinuity, northeastward to Oak lake, which lies on the boundary immediately west of Saganaga, and eastward to West Seagull and Frogrock lakes. At this limit a coarse syenite, with scattered, large angular individuals of quartz, intervenes for a distance of about twenty miles along the national boundary and south of it. This syenitic belt is the crossing of the Giant's Range, which trends from the east-northeast toward the west-southwest. At Gunflint lake occur the first conspicuous exposures of the Animike. The norhwestern swell of the lake stretches easterly and westerly into a couple of bays bordered on the north by the Saganaga syenite and on the south by hills of Animike slate. On the southern side of the eastern, or Black Fly bay, the two formations are traceable almost to the eastern extremity, where a breadth of not over twenty rods separates the two shores. The hill on the south side is crowned with gabbro.

The lake is bordered on all sides by dark shales of the Animike gently dipping southward, except about a mile near the middle of the north shore. Here (Halt 1353, see map) a very different formation comes into view. It consists of slates, mostly argillaceous and parophitic, standing vertically and striking N. 72° E. An excursion of half a mile into the interior shows

this formation continuous. The surface rises in a succession of parallel, interlocking high ridges, all having the same aspect as the cliffs on the shore. At about half a mile, the slate begins to be interstratified with layers more or less inclining to a micaceous slate. Continuing northward in the expectation or finding mica-schist fully developed, gabbro suddenly appears in a thin bed covering the crest of the hill, and concealing the formation underneath.

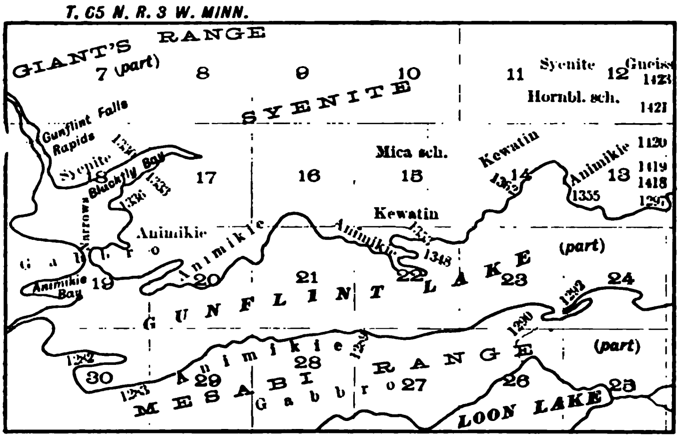

Fig. 1. Outline of Gunflint lake, with the exclusion of the eastern extremity.

The American territory covered is from the government plats. The section lines of the American survey are extended over the Canadian territory, and the principal features of the Canadian shore have been located by means of bearings taken from points fixed by the American survey.

Westward from 1353, the vertical schists can be traced nearly to the head of the little bay, where the Animike-covered opposite shore is not over one eighth of a mile distant. Eastward from 1353, the vertical slates rise in high cliffs for half a mile, and the formation is traceable, sometimes capped with gabbro, to near 1355, where it strikes inland, leaving the shore occupied by Animike. In this distance of a mile and a half from the head of the bay, the iron-bearing shales of the Animike rise

above the water-level in two or three places, and at 1362, they come within seven feet of contact with the vertical slates.[1]

Subsequently, I made with my brother, a traverse from another point of the shore, Halt 1297, due north for over a mile, along a line previously measured by surveyors employed by Sedgwick & Brotherton of Chicago. The gabbro at this point, comes down to the shore, but Animike slates are seen rising from beneath it at the distance of a third of a mile (1418). At half a mile inland, vertical slates are found rising in a hill slope. These are lithologically identical with those at 1353, and lie in their strike at the point of disappearance near 1355. A few rods beyond, across the strike, the slates become a porphyritic, sericitic argillyte, weathering much like the porphyritic porodyte of Vermilion lake,[2] but with feldspar individuals along with the quartzitic. Still beyond, the porphyritic slate becomes interbanded with thin layers of uralitic hornblende schist—five hundred alternations of which I estimated in the space of three rods. This condition is soon succeeded by well established uralitic hornblende schist, in a belt eighteen rods wide. This if much contorted, showing proximity to the ancient seat of some powerful dynamic action. The next ridge has the weathered aspect of syenite, and consists of quartz, white orthoclase and uralitic hornblende, aggregated in a gneissic condition. Well characterized Saganaga gneiss is reached at the distance of a mile and a quarter from the lake shore. Fuller details of the interesting lithological transitions observed will be given hereafter. The stratigraphical relations noticed on this trip are illustrated in the subjoined figure.

Another traverse was made by Mr. Stacy from near Halt 1355, a mile west from the last mentioned. The vertical schists were found to continue from the shore for a distance of three quarters of a mile, when the usual transition to micaceous strata occurred, and at a mile from the lake, gneiss was fully established. Not far beyond this, the rock seemed to be well marked syenite

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[1] These observations were made in August, 1887. As no record had been published of any observed superposition of Animike on the Vermilion slates, I forwarded an announcement to the AMERICAN JOURNAL OF SCIENCE, which appeared in the October number.

[2] See the fifteenth Ann. Rep. Geol. Surv. Minn. p. 20, etc.

The belt of crystalline schist was found a quarter of a mile wide.

This range of slates was visited by N. H. Winchell, in 1880. and he reported it as "underlying the quartzyte and gunflint

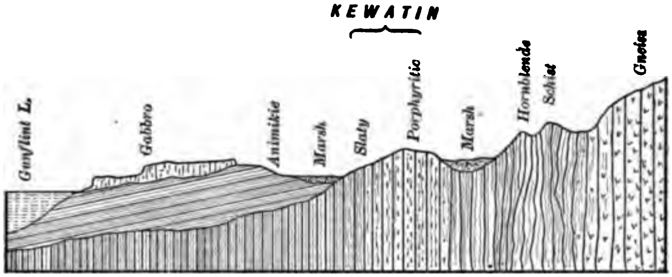


Fig. 2. Junction of Animike and Kewatin.[1] Vertical dimension exaggerated. Section observed on the north shore of Gunflint lake.

beds [Animike] apparently unconformably. At least, it is another and distinct formation from the slates at Grand Portage."[2] "The close proximity of this flint and jasper locality to the next great underlying formation (syenites and slates) makes it one of great interest to the geologist, but so far as scrutinized, as yet, the true relations of the two formations are not revealed by anything here seen, [just east of the Narrows—see fig. 1] though there seems to be an unconformability between them."[3]

In the October (1887) number of the American Journal of Science, appears the second part of a very important discussion from the pen of professor R. D. Irving, in which his figure 9 presents a fundamental resemblance to my figure 2; but his interpretation of the facts is quite different from mine. Professor

[1] The vertical schists are here designated Kewatin because supposed to be included in the original "Keewatin" of Lawson. The spelling is simplified; but if this term is to be adopted, it ought to be conformed to the established orthography of Chippewa terms. This is properly pronounced Ke-way'-tin—not Ke-wah-tin, and ought to be spelled Ke-wa-tin or Ki-wé-tin. (See "Instruction for research relative to the etymology and philology of America," by George Gibbs, in Smithsonian Miscellaneous Collections, No. 160; also, Contributions to American Ethnology, vol. 1, pp. 249-51; vol. 3, pp. 443-5.)

[2] N. H. Winchell, Ninth Ann. Rep. Geol. Surv. Minn. (1880) p. 82.

[3] N. H. Winchell, Tenth Ann. Rep. Geol. Serv. Minn. (1881), p. 88.

Irving appears to regard the vertical schist as part of the assemblage of crystalline schists and gneisses holding a position beneath the iron-bearing schists of Vermilion lake while I consider them without a doubt, to be the equivalent of the iron-bearing and iron-enclosing schists themselves. In my view, consequently, the Animike slates of his figure 7 are quite another thing from the "Vermilion Iron Series" of the same figure. The grounds of my divergent interpretation of the approximated formations will be fully stated in another place.

The junction between the Animike slates and the underlying vertical or Kewatin slates is interestingly shown at other localities. At the southeastern point of Epsilon lake, at the end of the portage from Zeta lake,—both in T. 64, R. 6 W.—occurs a high cliff of dark argillyte cleaved by smooth planes running N.30° E, and having a southward dip of 75°. But the faces of the sheets are marked by a fibrous striation dipping westerly at an angle of 54°. This, if a sedimentary dip, is such that the Ogishke conglomerate, which disappears northerly not far from this spot, would be found underlying.

A third of a mile north from here, on the east side of Epsilon lake, dark argillyte of character similar to the last, forms a high bluff in which the usual cleavage planes strike N. 35° E, and dip southward 67°. Here, however, are colored bands running across the faces of the laminæ, and dipping westward at an angle of 14°; but further examination shows these bands to be lines of bedding which dip southward at an angle of 60°. Here then, appear to be two localities in which the usual vertical slatiness exists, while the bedding is quite unconformable. But these features belong to the whole exposure, and the slate presents lithologically the characters of the argillytes of the Animike.

Half a mile beyond the last locality, and on the north side of the lake, is an outcrop of bluish, somewhat irregular, argillyte, which rises in a hill a hundred feet high, separating Epsilon lake from the southern bifurcation of Arm IV of Knife lake. The formation here posesses the usual schistic structure of the vertical schists of the Vermilion iron-bearing schists, but discloses no diagonal ribboning on the lateral surfaces of the sheets. The schistosity is evidently coincident with the sedimentation planes.

Finding characteristic Kewatin slates within half a mile of characteristic (but rather steeply dipping) Animike slates, it became very important to find their junction, which must occur at some intermediate point. Happily, a careful search brought the junction to light. At this point is a low projecting bluff of slate, in which the usual vertical cleavage is conspicuous at all points, and careless observation would pronounce the whole exposure one in character and age. Careful inspection, however,

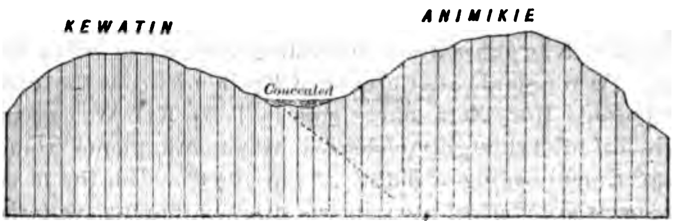


Fig. 3. Junction of Animike and Kewatin. South side of Epsilon lake, T 64, R 6 W, Minnesota.

shows the boss of slate on one side to possess a ribboned character dipping S.43°, a dark complexion and very smooth cleavage; while that on the north is a rough and older looking slate, with no graining or ribboning unconformable with the schistosity. On the contrary, due research discloses the existence of bedding planes conformable with the schistosity, and also giving evidence of their sedimentary origin. In short, we have here Animike slates on one side resting uncomformably on the Kewatin slates of the other side. The precise junction is not exposed, that being, as usual, more eroded than the masses on either hand, with the depression covered by detritus.

Similar but less conclusive observations at many other points led me to the conclusion that many of the depressions in the old eroded surface of the Kewatin, in the region from Gunflint lake to Knife and Sucker lakes, have been filled with Animike sediment, and both formations subsequently subjected to the common influences which have imparted to both that wonderfully persistent and uniform vertical schistosity which is so striking a feature. The most eastern discordance known is in sec. 1, T. 64, R. 3 E.

I wish to cite one more instance of the local relation of the Animike to the gneissic rocks of the region of Gunflint lake. From the western extremity of the northern swell of the lake, a distance of two miles west along the northern section line of sections 24 and 23 of T. 65, R. 4 W, and then a quarter of a mile south along the western line of section 23, brings us to an outcrop of the Animike which incloses a heavy deposit of magnetic iron ore. The outcrop is less than a quarter of a mile south of a ridge of gneiss which marks the southern boundary of the Giant's Range. We find exposed here in a bluff, a bed of magnetite about six feet thick, underlaid by eight feet of thick-bedded rock of which the upper part is composed of fine grains of quartz and orthoclase, with argillaceous matter, and the lower part is bluish, finer and more compact; but neither of these rocks has been particularly studied. The dip here is 13°. In the immediate vicinity a test pit has been sunk (fig. 4) which

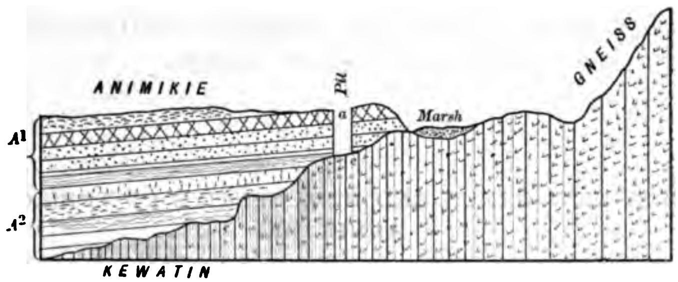


Fig. 4. Junction of Animike and gneiss. Two miles west of Gunflint lake.

G, Vertically schistose gneiss. a, The principal iron beds.

K, Vertical Kewatin (not seen here). e, Layer of gravelly earth.

A^1, Nearly horizontal Animike, upper beds.

A^2, Animike, lower beds of the vicinity.

passes through all the Animike beds present and terminates on the gneiss. The magnetite here is from three to four feet thick, but varies in quality both horizontally and vertically, ending downward in a broken, cherty zone. At the plane of contact between the Animike and the gneiss is a layer of brown earthy matter about four to six inches thick. In places, this appears a sheet of Animike rusted and decayed, but the greater part of the bed plainly comes from the decay of the gneiss; for it

abounds in gravel which apparently represents the quartz. This bed probably continues southward until the Kewatin becomes the subjacent formation; and the latter, according to uniform observation, must stand in vertical conformity with the gneiss.

It is noticeable here that the lowest beds of the bluff are wanting in the pit. The higher beds appear to extend farther northward, as if the gneiss had been subsiding during the deposit of the Animike. The iron, too, is located in these beds, though generally the iron horizon is considered to belong in the lower part of the formation.

Similar unconformities of the Animike as described, on the iron-bearing series as described, are repeated, apparently, in the Marquette region. But in this place I must restrict my remarks to Minnesota.

If the magnetitic, Huronian Animike reposes unconformably on the hæmatitic, uncrystalline, super-Laurentian series of the lake Superior basin, we have a wide-extended system of slates which invites serious taxonomic consideration.

ON A NEW GENUS AND NEW SPECIES OF TUBICOLAR ANNELIDA.

BY PROFESSOR S. CALVIN.

I am indebted to professor B. Shimek of the Iowa City High School for a number of fragments of *Acervularia davidsoni* Ed. and H., which contain as enclosures the shells of a very peculiar and very interesting tubicolar worm. The specimens were procured at Robert's Ferry in Johnson county, Iowa. So far as I now know the tubes of this worm are only found embedded vertically in the solid coralla of *Acervularia*. Furthermore the species, except at the locality mentioned, must be exceedingly rare. Of the many hundreds of specimens of *Acervularia* that I have collected, or seen exposed at the quarries or along the natural exposures near Iowa City, at Littleton, or at numerous other places where this coral abounds, none have shown any indications of the tubes in question. If the tubes

were small and inconspicuous, we might suppose that they had been overlooked, and that further examination would show them to be more generally distributed than we are at first inclined to believe; but in place of being inconspicuous the tubes are not unfrequently a quarter of an inch in diameter and two inches in length. Moreover, unlike all other worm tubes of the group known to me, these are uniformly coiled in a long, loose, somewhat irregular spiral, and the successive brownish volutions stand out conspicuously on the freshly fractured surfaces when the coral is broken in the right direction. It would probably be a better description of the actual state of affairs to speak of the tubes as twisted rather than coiled. The volutions while for the most part in contact, lack the regularity of the volutions of *Loxonema*, *Murchisonia* or any of the long spired gasteropods, resemblance to which a first glance is likely to suggest. The irregularities about the sutures remind one of the effect of torsion, and the tube diameter is not unfrequently diminished between two contiguous volutions. All the irregularities and appearance of twisting, however, are due to peculiarities in the mode of growth and not to any agencies that have affected the tubes since they were formed.

In all the specimens before me the spiral is sinistral. A section across the axis is circular or sub-circular. The surface is marked by transverse lines of growth that are approximately parallel and horizontal throughout the whole length of the tube, any change in the direction of the successive parts of a given volution producing no change in the general parallelism of the lines of growth. It would seem as if the mouth of the tube had been always horizontal, quite regardless of the fact that the ascending spiral axis during the growth of any simple volution was directed successively to every point of the compass. The upward growth of the tube was effected by the addition of equal vertical increments all around the margin of the aperture, and yet, notwithstanding all this, the creature managed to coil around an imaginary vertical axis with surprising regularity. There are no longitudinal markings of any kind, except that very rarely there are faint grooves and ridges, evidently due to contact of the edges of the septa of the coral with the outer surface of the tube. The tube tapers very gradually, and the

spiral axis never departs horizontally as much as a half tube-diameter from the imaginary vertical axis.

While the worms here referred to were not social, yet a large number may be found embedded in a single corallum. Their occurrence in the midst of the coral substance, closely and firmly embraced by it on all sides, reminds one of the Serpula tubes in the Meandrinas, from the modern reefs of Florida and the West Indies. The Serpulas that are found associated with Meandrina, however, are attached first to the side of the corallum, usually to the surface of a dead portion near the base, and, extending upward until they reach the living part, are by the lateral growth of the colony enveloped in the stony secretion. From the point of earliest attachment, all along up the side, the Serpula tube is soldered fast to the corallum. The tube may be variously flexed; but the one condition that it must adhere to the surface of some solid body throughout its whole length, precludes the possibility of spiral growth. The mouth of the Serpula tube, after it is fairly enclosed in the stony secretion of Meandrina, does not usually advance beyond the surface of the coral. The growth of the tube and the growth of the coral seem to progress with equal step.

Now it seems to me that the worms that became associated with *Acervularia* at Robert's Ferry could not have been first attached to the sides of the corallum, but must have settled down among the living polyps on its surface. The embryonic shell was attached by its tip or apex, not by its side. The upward growth of the coral clasped and held it firmly as fast as it was formed. Probably the tube always projected a little beyond the surface of the corallum. This would indeed seem to be necessary in order to afford perfect freedom for the swinging of the worm around a vertical axis; a swinging which was necessitated by the conditions of spiral growth.

The worms that infested *Acervularia* were related in some respects to *Serpula or Serpulites*. The tube is simple, without vesiculose walls or internal annulations. It differs therefore from the complex tubes that characterize the genus *Cornulites* of Schlotheim, as well as from the small tubes, found in colonies on which Nicholson (American Journal of Science, third series, vol. iii, p. 204,) founded his genus *Conchicolites*. Nor is there

anything to snggest generic relationship between these worm tubes of *Acervularia* and the *Salterella* of Billings, (Pal. Fossils, vol. i, p. 17.) This last genus comprises "small, slender, elongate-conical tubes, consisting of several hollow cones placed one within another." The pretty spiral worm tubes of the genus *Spirorbis* are coiled in a plane and attached by one side only. The tubes that constitute the subject of this paper differ from all others known to me in being more or less regularly coiled around an elongated axis, and in being from the beginning of their growth supported on all sides. I therefore, provisionlly at least, propose to make them the type of a new genus as follows:

Streptindytes, n. g. Worm solitary, inhabiting a simple calcareous tube spirally coiled around an elongated imaginary axis. Diameter of tube increasing very gradually from the apex, sometimes constricted between the volutions. Tube walls thin, marked externally by parallel lines or annulations of growth. Mode of growth apparently requiring that the tube be supported equally on all sides. The typical species growing vertically in corals.

Streptindytes acervulariæ, n. s. Tubes with the spiral sinistral, growing in greater or less numbers in coralla of *Acervularia davidsoni*. Tubes varying from one-eighth to nearly one fourth of an inch in diameter, and from one to two inches in length. Surface marked by fine parallel lines of growth. No longitudinal striæ. Spiral somewhat irregular. In a typical example, where the tube is about one eighth of an inch in diameter, the distance from middle to middle of two contiguous volutions is one fourth of an inch.

Found in strata of the Hamilton period, Devonian age, at Robert's Ferry, Iowa.

Species of *Streptindytes* may have lived in other corals than *Acervularia*. They may have lived indeed embedded, tip downward, in soft mud, or in any other situation where the growing tube would be subject to similar conditions on all sides. They could never have had the habit of *Serpula or Serpulites*, the genera to which *Streptindytes*, in the matter of shell structure, stands most closely related.

Finally it is highly probable that at least specific modification was necessary to enable our Robert's Ferry species to establish

itself and live successfully in the midst of a growing colony of *Acervularia*. To have lived in other genera of corals or in soft sediment would have required still different adaptive modifications. There is therefore little impropriety I hope in calling the worms of our new species *Twisted in-dwellers of Acervularia*.

Iowa City, Iowa, Dec. 7th, 1887.

NOTES ON THE FORMATIONS PASSED THROUGH IN BORING THE DEEP WELL AT WASHINGTON, IOWA.

BY PROFESSOR S. CALVIN.

The deep well at Washington, Iowa, is located in the eastern edge of the city. From the surface to a depth of 350 feet the boring passed through superficial deposits of drift and modified drift. There were beds of gravel, sand, and clay, presenting the usual characteristics observed in the regions of modified drift in Iowa. The blue clay, so widely distributed in all the drift-covered portions of the Northwest, occurs conspicuously in the deeper borings from the superficial deposits.

The "forest bed" was reached at a depth of 115 feet. Peaty matter with the usual accompaniment of pieces of wood and twigs of trees were brought up from this depth. By all means, however, the most interesting specimens obtained from the "forest bed" were ten small cones, evidently cones of the black spruce, *Abies nigra*. This, so far as I now recall, is the first time the fruit of the old interglacial forest trees has been obtained in this state. The species indicated by the cones is suggestive of climatic conditions somewhat more rigorous than those which now obtain in the latitude of Washington, Iowa.

A dark shale, more or less calcareous in some of its layers, was encountered from 350 to 432 feet in depth. This probably represents the lower part of the Kinderhook beds, as this formation is defined by White, *Geol. of Iowa*, 1870. About three miles west of the point where the boring in question is made, rocks of the age of the Upper Burlington limestone occur near the surface and are quarried somewhat extensively for building purposes. At the well the Burlington and part of the Kinderhook slates had been removed prior to the deposit of the

earlier drift, and 350 feet of superficial *detritus* scarcely suffice to bring the surface up to the level of the limestone at the quarries west of the city.

At a depth of 458 feet the samples show a light colored magnesian limestone of rather fine texture. The borings from this depth contain the only recognizable fossils found below the "forest bed." Fragments of *Atrypa reticularis* Lin. and of *Athyris vittata* Hall, indicate very clearly the horizon of the Hamilton limestone and shales as these are developed at Iowa City, Davenport, or Independence, Iowa.

With some alternations of shale and limestone the Devonian deposits extend to a depth of 500 feet. At this depth the last of the borings referable to the Devonian were obtained.

The next samples are marked 532 feet and consist of calciferous sandstone, which at 585 feet passes into a purer sandstone and as such is continued to a depth of 632 feet. As, however, the next sample is marked 702 feet, we may infer that the sandstone extends almost to that depth. This 170 feet of sandstone evidently represents the deposits of the Niagara period.

At 702 feet we find a fine bluish or greenish shale, identical in all respects with shales of the Hudson River group, as seen in the bluffs at and below Bellevue, Iowa. Clay shales, sometimes with an admixture of sand, and again with some calcareous matter, are continued down to a depth of 793 feet. This group of shales are plainly referable to the Hudson River shales of Hall or the Maquoketa shales of White.

Grayish limestones, not dolomytes however, from 803 to 963 feet are probably the equivalents of the Galena limestone of eastern Iowa.

At 1020 feet the borings consist of dark, fine-grained limestone mixed with considerable carbonaceous shale. There is little difficulty in recognizing in this limestone and shale the Trenton of Iowa and Wisconsin. The bits of carbonaceous shale are quite rich in bituminous matter and burn with flame and smoke when ignited. Similar shales, that one may light with a match, constitute partings between the beds of Trenton limestone at Boat-Yard Hollow, opposite Dubuque, at the mouth of the Turkey river, and at many other places in Iowa.

The Trenton limestone with its ordinary lithological characters in the Northwest continues down, as shown by the borings, to a depth of 1059 feet. At 1082 feet is a bed of sandstone, and from 1084 to 1095 feet is an arenaceous shale, both of which probably belong to the Trenton series.

From 1100 to 1200 feet the borings show the usual characteristics of the St. Peter's sandstone. Some of the specimens are pure white, granular, resembling refined sugar. Others are brownish or reddish, stained with metallic oxides. At 1145 feet, the sand when taken out was pure white, but owing to the combined action of the atmosphere and moisture it has since changed to a bright red. The change is most marked at the sides of the bottle, the sand in the middle retaining nearly its original color.

At 1228 feet is a thin bed of bluish shale that I am inclined to think represents the Lower Magnesian limestone. This can be better determined after the boring has progressed somewhat farther. If the conclusion is correct, then a grayish sand marked 1230 feet represents the upper part of the Potsdam series.[1]

The geological horizons that may be determined with a great degree of certainty are the Hamilton, Hudson River, Trenton and St. Peter. A noticeable fact and one of great interest is the absence of dolomytes. In place of the dolomytes of the Niagra period we seem to have 100 feet of sandstones. The place of the buff or cream-colored, coarse, granular Galena limestone seems to be filled with a grayish limestone not dolomitic. Finally, if my conclusion regarding the shale at 1228 feet be correct, we have the Lower Magnesian limestone represented by a bed of clay. While the deposits of the Lower Magnesian limestones were going forward in northeastern Iowa, the place now occupied by Washington, Iowa, was more remote from the then-existing shore line, and was more deeply submerged than any point at which we now find these limestones exposed. The same may be said with reference to the other dolomitic formations. Can it be that dolomyte is only formed near the shore? The Hudson River shales, the Trenton limestone and

[1] Prof. Calvin here probably means to indicate the upper part of the St. Croix formation of the Mississippi valley.—N. H. W.

the St. Peter's sandstone pass away out under Washington practically unchanged, but dolomitic deposits seem not to have extended very far seaward.

THE FUTURE OF NATURAL GAS.

BY E. W. CLAYPOLE.

The excitement over the wonderful supply of gaseous fuel which began about four years ago and has since risen to fever-heat will form one of the most remarkable events in the history of economic geology in North America—second only, if second, to the great oil-craze of twenty-five years ago. The narrative stripped of all exaggeration is sufficiently striking to sound more like a chapter from the Arabian Nights, than a plain unvarnished story from actual history. Both may be fairly entered among the "fairy tales of science." The wild speculation—the mania which marked the years from 1860 to 1865--was repeated on a somewhat smaller scale in 1885 and 1886. As a forest of derricks arose in the few favored spots in Pennsylvania to bore for oil so has a similar forest arisen in almost every state in the Union to pierce and probe the strata in order to discover whether or not they contain any store of natural gas. The result as we all know has been that a few places have found a rich supply of fuel ready to spring forth and do their bidding at a merely nominal cost, while the greater part of the country has proved to be barren territory, yielding only "dry holes."

Foremost among these favored spots is Pittsburgh near which have been developed surprising quantities of this clean and cheap fuel, the effect of which has been to render the once dirtiest city of the Union comparatively smokeless, and its air comparatively clear.

Second to Pittsburg, but second only at an enormous interval, comes Findlay, O., which town has also found large stores of gas. Many other places in different parts of the country have had more or less success in their search and are enjoying proportional advantage.

The new fuel has naturally attracted manufacturers to the places where it can be obtained, and the towns that possess large

gas-wells have exerted their utmost endeavors to encourage this immigration by offering free sites and other privileges to firms that would consent to remove.

Other towns felt that they were placed at a disadvantage, and seeing no reason why they also should not obtain gas began to sink wells in quest of it, in almost all cases without success. Many of these explorations were undertaken and carried out against the advice of geologists, who saw no prospect of any thing but failure and whose prophecies have in nearly all cases been literally fulfilled.

A review of the whole subject so far as it has been yet developed, suggests to every observing mind the query, "What is to be the future of natural gas? Is it going to be a permanent addition to our natural working resources—an addition that can be relied on for ages to come—or will it prove a passing, fitful supply, likely to run out almost before we have learned how to use it? Will it be a star or a meteor, a lamp or a will-'o-the-wisp?"

Whatever may be the opinion of the dealer and the speculator whose interests are bound up in the gas-supply, the geologist has but one answer to this question. He feels confident that however great and surprising may be the present exhibition of natural gas it will infallibly ere long run out. It may not be easy to convince people generally of the truth of this opinion, because it is contrary to their wishes. But there can be no doubt of its essential truth, and that a comparatively short time will witness the exhaustion of all the roaring gas-wells that are now vomiting forth their vast supplies of natural fuel. Their roar will grow less and less until it dies into silence and their glowing flame will grow dimmer and dimmer until it fades into darkness.

What ground, we shall be asked, is there for this melancholy foreboding? Why prophesy evil things in this our day of prosperity and abundance? Why play the croaker amid general exultation? We reply that it is better to know the truth even if unwelcome than to nurse a falsehood till it bursts as a bubble, and leaves us with nothing instead of our fancied possession.

Though the exhaustion of our supply of natural gas has been

an unwelcome prediction yet a calm and unprejudiced review of the evidence points strongly to it. Look at the present condition and read the past history of the once famous oil-fields of Pennsylvania and see what they can teach us. Read the story of the great Pennsylvanian gushers and note their present state. It is almost mournful to walk through those scenes of fabulous wealth and waste only twenty years old. It is saddening to visit the great Franklin oil-field of Venango county and see the hill-side dotted with derricks standing over wells from which within a decade or two flowed forth dark green streams of oil at the rate of one, two or even three thousand barrels per day. There they still stand thick together like giant skeletons in the forest. On each one seems to be written "Ichabod," "the glory is departed." Only by extreme care and economy can these fabulous monsters of the past be made to yield enough to pay their costs. A small solitary steam-engine stands amid a group of wells and by means of long swaying rods works a pump in each. Slowly the piston rises and falls and the long rods creak and groan alone among the trees. No man is near. Night and day they toil unwatched and untended save for an occasional visit from the engineer when anything gives way. And as the result of all these labors a small trickling stream of oil flows down the hillside through an iron pipe into a barrel placed below. Even of this small stream the greater part is only brine, worthless and troublesome, and the net results from some of these giants of old is but one, two or three barrels of oil daily.

Substantially the same story may be told of all the oil-regions. Exhaustion stares the visitor in the face everywhere. Their day is past. The quiet old towns that sprang into sudden energy and activity during the oil-craze have sunk back to their former quietness and lethargy. The new oil towns that leaped into sudden being at the touch of the enchanter's wand have sunk as quickly as they rose and the grass is now growing in their once busy streets. Corner lots are at a discount, and often the ruins of derrick and engine house alone mark the spots where once a "city" stood. Goldsmith's deserted village has been enacted more than once in northern and western Pennsylvania.

And as it has been with the oil-fields of the past so will it be with the gas-fields of the present. They too will run out and fail and the tradition of their greatness will alone remain. The great Karg well at Findlay will cease to blow, and the greater roarers of Murraysville, Grapeville and Washington will also become silent. Findlay will have no more gas, and Pittsburg must find some substitute for its present supply of this clean natural fuel.

Nor are the reasons far to seek. The geological connection of oil, gas, and salt water is very close. Where the strata are arched upward and the conditions for producing oil and gas are present there they accumulate, and the gas being the lightest rises to the top and is confined beneath the crown of the arch. Next comes the oil and forms a stratum below the gas. Lowest of all is the salt water. In such places then we have at three difierent levels three stores of gas, oil and brine respectively. Hence the uncertainty in the yield of a well until the territory has been explored. A hole sunk near the crown of the arch will penetrate the upper reservoir and gas will issue. One sunk farther down the slope of the arch will enter the oil layer and yield oil which is forced out by the pressure of the overlying gas. And a third sunk yet further from the crown of the arch will yield salt water.

This, so far as we have been able to discover, is the usual structure of the ground where oil and gas are found in quantities. There may be and no doubt there are exceptions, but they do not invalidate the general rule.

Now if we consider the subject a little farther, we shall see that as a necessary consequence of this structure, when the wells have drawn off a certain part of the store of gas the oil will rise under the crown of the arch and eventually will reach the bottom of the well, when it will begin first to *spurt*, then to *spray*, and lastly to *yield* oil, the supply of gas at the same time proportionately diminishing. Later still, the continual draught on the oil reservoir will so far exhaust it that the brine will in turn rise and reach the bottom of the well. The flow of oil will then slowly cease and salt water will take its place, as is now happening in the old wells of Franklin, Pa. The last

chapter in the history is then written. The well is dying and its extinction is near at hand.

The analogy of the past· enables us to develop the future. The history of hundreds of wells has been as above given—gas in their early days, oil later, and lastly brine. Nor is there any reason to suppose that the existing wells will, in spite of their vast present production be any exception to the general rule. They too will fail and cease to flow. The cities that now so complacently regard their store of gaseous fuel as practically inexhaustible will be disappointed and will rue too late the enormous waste of the past. The preëminence which they now enjoy from this cause will pass away and they will be as they were before natural gas was discovered.

The evil day may in some cases be staved off by sinking new wells and by the discovery of new territory adjacent to the old, but this can be only a temporary expedient, and as the petroleous glory of Franklin has passed away so will also pass away the gaseous glory of Findlay and Pittsburg.

Some of our readers may ask how long it will be before these sayings are fulfilled. A definite answer to this question is impossible. We know not the extent of the reservoirs in the strata below us, nor the rate at which the gas is now coming off. But it will not be very long. The golden harvest will be of short duration, and those who are gathering it will do well to keep this truth constantly before them.

It does not follow that a year or two will see the exhaustion of the supply, though our own opinion is that before that time comes signs of the end will not be lacking. Already rumors, in most cases soon contradicted, have been afloat that the great Karg well at Findlay is beginning to spurt oil. It is very difficult to learn the exact truth about the Pittsburg supply, especially as new wells are constantly drilled and their supplies turned into the mains. But time will show, and when the yield seriously falls off concealment will be impossible.

Some will object and say, "Is not gas being continually formed in the earth?" Possibly so. We do not suppose the processes of nature in the past are suspended in the present. But granting this uncertainty, the rate of formation must be far inferior to the rate of exhaustion. Indeed it is probably so

slow as to be perfectly inappreciable by the side of the enormous consumption. Our store of natural gas is a capital stock on which our draughts are growing greater from year to year, and the end is obvious. By and by they will be returned with the words written across them "No effects."

And what then? Shall we go back to coal and coal smoke, or shall we devise some way of making gas that will be less costly than the present, and can be used for manufacturing purposes. It is as yet impossible to say what the ingenuity of man can do when stimulated by the prospect of advantage. But this time, and no long time, will show.

EDITORIAL COMMENT.

GEOLOGY IN THE EDUCATIONAL STRUGGLE FOR EXISTENCE.

In the pressure of subjects for recognition in the educational curriculum, geology is one which has had to struggle under great disadvantages. Generally, geology is a study among the least and last appreciated by the framers of educational opinion, and the controllers of educational practice. It is the last of the natural sciences to be admitted into courses of study; when admitted, it is generally assigned to a stage in the course at which the student's tastes are already bent in other directions; when the time at his disposal has been largely preoccupied, and he is looking with some degree of impatience for the conclusion of his academic career and his entrance upon the arena of business life. Under such circumstances, geology is apt to be a subject held in low esteem by the educational public and the student community. The controlling authorities partake of the general impression; and from this results a disadvantage greater than all the others—one which prevents a study of capital importance and transcendent interest, from conquering, as on its merits it would, all the disadvantages of relative position in the curriculum.

To present the subject under a concrete aspect, let us consider the educational work in the average university. The student of law feels that he is preparing himself for the acquisition of a respectable livelihood. He is thinking of fees and fame and the prizes of the political arena. These ends, either immediate or more remotely prospective, are ever before him. They are living motives; they centralize his thoughts and his efforts. He works with zeal; his fellow-students actuated by the same motives, are numerous; the department of law, so respectable in numbers, must be made respectable in outfit; the controlling powers feel that it is a department of the university to be specially fostered, and it is so fostered. The student of medicine, in like manner, feels that he too is acquiring the means of material advancement. He is thinking of fees, honorariums, comfortable, and then luxurious,establishments. He is looking to rapidly made fortune, and middle life repose. The student of pharmacy is a student of the means of lucrative business. The practical and profitable aims before him command his steady attention and sustain his unflagging energies. The dental college is a scene of similar assiduity and expectation. All work, all hope, all desire centre in the generous income which educated and competent practice is sure to bring. Here, as in other professional schools, an external motive sustains industry, unites numbers in a common interest and pushes it to a conspicuous position and commands the respect and care of the ruling authorities.

If we turn to the schools of civil and mechanical engineering, we discover similar stimuli acting on minds perhaps more cultured, but therefore more susceptible to motives drawn from the possible succeeses of a future career. The young engineer will acquire fame for his skill. He will come into profitable request; he will plan great and novel bridges; he will carry railway lines in seemingly impossible places; great undertakings will demand his services, and great rewards will requite them. Else if his ambition is moderate, he will superintend some workshop or some great industrial establishment, and earn in salary two or three dollars in the same time as his late professor earns one. It is understood without saying, that the school, in its diversified adaptation to the needs of various seekers for means of livelihood is thronged with devotees. There is no interest so moving as a

material interest. It is self-sustaining, unremitting, and demonstrative. It commands admiration for its assiduity and earnestness. It commands respects for the numbers which it unites in a common aim, and for the revenue which numbers bring to the university. The outside world appreciates an education which it can call "practical." It understands the value of a department in the university which qualifies young men to accumulate money. That, it thinks the chief end of all education. So the outside public unites with the inside authorities in expressing their satisfaction with the popularity of the school and the abundance of fees which it brings. They also unite in tendering it all the support and fostering care which it needs. They supply it with requisite equipment and an adequate corps of instructors and assistants. In the abstract, these things are all exactly as they should be. Great good results from bringing all these professional and industrial schools to as perfect a state as possible.

If we turn to the academic department of the university, we obtain a further comprehension of the nature of the environment of the geological interest. Here, concisely stated, we find pursued linguistic studies, mathematical studies, philosophical studies, literary studies, and studies in physical and natural science. By immemorial prescription, the linguistic, mathematic and philosophic studies have enjoyed the first place in position and in general esteem. The *trivium* took possession of the university by right of discovery, and, in its modern guise, has asserted with haughty and militant exclusiveness, the righteousness of its appropriation. As the trivium supplied the means of a liberal education in an age when the sum of non-professional human knowledge was a trivium, so it has always asserted that the old trivium, with a seasoning of mathematics, is the chief essential of a liberal education, even since the field of human knowledge has become so enlarged that the trivium covers but a small fraction of it. The representatives and devotees of the traditional culture proclaim that there is no other real culture; and since, in scholastic circles, they constitute a large majority, they succeed in creating a public sentiment accordant with their pretension. Though this public sentiment is not the popular one, it is imbibed largely by young men seeking a

liberal education, and they are induced to devote four formative and determinative years of their education to the same studies as occupied the youths of the dark ages. The high educational authorities do not inform them that real culture would result also from the devotion of four preparatory years to the modern languages and the natural sciences, and the faithful prosecution of a collegiate quadrennium inaugurated by such a preparation. In all sincereity and earnestness, therefore, the candidate for a diploma of culture places himself in a position where the old trivium appropriates the lion's share of his efforts during a period of six or eight years. The classical department of the university is thronged, consequently, with those who have been taught, and honestly believe, that no liberal education is possible without such offerings of time, labor and money as it exacts. Of classical learning in the abstract we have nothing adverse to offer. We wish only to make clear the nature of the conflict for educational existence which geology is compelled to wage.

Among the more modern subjects which have gained recognition in the collegiate curriculum, the class which may be called "literary" possesses marked advantages over the scientific —especially those studies in natural science which are not regarded as leading directly to some money-making profession. Chemistry, in its accessory relations to medicine, pharmacy and metallurgy, falls into the fortunate category of "practical" and "productive" studies, and has little fight to make in securing appreciation and support. But the literary group of studies obtain appreciation and support through the relation of their subject matter to popular literature. They present no array of technical terms or conceptions. Their language is that of the intelligent public, and their themes are those which beforehand occupy the thoughts of the masses of intelligent readers. Literature and history, in their educational pursuit, make comparatively light demands on the powers of abstraction, induction and reflection. Their themes also lie close to the personal experiences and interests of the reader. They are narratives of social life, dressed in pleasing style, or of biographical adventure, or of national happenings in which a few heroic personalities constantly appeal to the personal interest of the reader. The subject-matter is easily comprehended, at the same time

that it moves the sensibilities and warms the imagination. We do not affirm that literature is properly restricted to compositions of a nature so nearly on the level of popular sentiment, but we take our literary critics at their word, and speak from the literary standard which they set up, and contemplate that public estimate of "literature" which their verdicts create and sanction. The undoubted facts being such as we have indicated, the predisposition to studies called literary, exerts upon the choice of students a controlling influence next to that of the fashionable affectations of classical culture. Literary studies, therefore, possess the adventitious power of pushing their own way, and guaranteeing their own prosperity. Because they awaken a wide interest in the scholastic community, they feel free to make large demands on the sources of financial nurture; and the almoners of such nurture feel justified in graduating their generosity to the standard of the popular sentiment.

Even within the circuit of the academic curriculum, there is often present a professional motive which predisposes toward certain lines of study. Not unfrequently the academic course is pursued with ultimate reference to a course in law or medicine. With legal aims, linguistics and literature—including as before, history and civics—are conceived to be more germane than the natural sciences. With medical aims, Latin and chemistry are thought to be more ancillary than the natural sciences. And among the latter, botany and zoölogy are thought to sustain more hopeful relations than geology. More frequently, the academic course is pursued with the purpose of engaging temporarily, or sometimes permanently, in the profession of teaching. The foremost question before the mind in such case is, for what department of teaching is the demand most active? The statement of the question suggests the answer. The chief demand is in those studies which the university pronounces prerequisites for entrance upon collegiate courses, and which by implication are the fundamentals of a good secondary or sub-collegiate education. In other words, the student who is aiming at a position as teacher, will seek to familiarize himself with linguistics, mathematics or literature. Where natural history and geology are not demanded by the university as preparatory for college, the schools will not offer preparation in

them. If they are demanded to a feeble or partial extent, the schools will make feeble or partial provision for them. In the schools, therefore, the central effort is made to supply a preparatory education which does not embrace natural history and geology. The student in the university aiming at service in the schools, prompted by self-interest, shapes his studies to the nature of the demands existing. We do not wish to leave the suspicion that we think it just for the schools to provide only, or chiefly, such sub-collegiate education as opens the way to college; but our purpose is simply to point out the facts, however deplorable or however commendable, which place the study of geology at a disadvantage.

When now, after such a survey of the relation of the different fields of university study to the means of earning a livelihood, we grasp the whole situation at one view, it quickly appears that geology, if pursued in college or lower school, must be studied from motives more purely unprofessional than in the case of nearly all other studies. But the simple search for knowledge possesses with most minds a less controlling influence than the search for means of support. Even in the collegiate or academic departments of the university, the professional motives find room for such activity that geology and natural history stand at a marked disadvantage. When we look more closely, we learn that the disadvantage does not really consist chiefly in numbers in attendance upon instruction, but in the lack of adequate and equal material sustenance afforded by the government of the university. The discrimination against these studies is prompted by three motives: 1st. The scholastic authorities entertain the traditional conceptions of the requirements for a liberal education, and are not sufficiently informed in the sciences to admit that they are equal means of culture; and, as the outcome of their prepossesions and their ignorance, succeed in turning the revenues of the university into the channels which they approve. 2d. The financial control of the university determines its policy partly by the recommendations of the scholastic authorities, and partly by the amount which a department of study is able to return in the shape of fees which students with professional aims feel willing to pay. 3d. The supreme government of the university participates in the popular opin-

ion that those departments and those studies are most worthy of support which sustain the most immediate relations to the production of wealth.

The final outcome of the conflict waged by geology for standing in the university, assumes form somewhat as follows: The smallest possible allowance of means is granted for carrying on the work of instruction and investigation. Other departments of instruction may be allowed numerous assistants, while that of geology, with similar necessities, has none or almost none—even for simple manual work. Other departments secure supplies of the means of illustration and investigation, while geology may plead for years in vain for some small purchase indispensible for work according to modern methods. Even in the ostensibly, and it might be added ostentatiously, equal distribution of appropriations for books, geology is placed at a double disadvantage. First, scientific works if illustrated, as they are apt to be, belong to a relatively costly class; so that a given allowance to geology secures less literature on the subject than the same allowance to history, English or Greek. The same may of course be said of zoölogy and botany. Second, of the relatively large allowance usually assigned for miscellaneous books, a very large proportion of those purchased might well fall to the charge of the literary and philosophic departments. They are largely accessory to those departments, while the taint of natural history or geology is enough usually, to consign a book to the catalogue of those chargeable to the special funds for those subjects.

We have drawn a picture of one of the most strongly colored cases. It is a case where scientific interests have no independent or exclusive endowmeut, or school, or standing; where every provision and regulation is at the dictation of the literary interests; where the executive and consultative authorities are identified with those interests; and the highest external control seeks only the recommendations which emanate from a single source. These various conditions may not be found united in one institution. There may exist, assuredly, collegiate and university institutions in which geology enjoys a better standing. There are institutions whose founding and expansion are as recent as the very modern expansions of the natural sciences,

and where these sciences were from the beginning granted a relative position worthy of their claims. There are institutions where the executive and advisory influences are in sympathy with the natural sciences and with the spirit of the age. We have no doubt that the number of such institutions will steadily increase.

Our object in offering these statements for record is twofold. We desire to call the attention of geologists and other scientific gentlemen to the actual state of the facts. The geological instructor and investigator is apt be so deeply absorbed in his efforts to advance and diffuse the knowledge of natural truth that he is scarcely conscious of the enormous inequalities of position in which he is placed. A general consensus of demands for rights will be more likely to improve the situation than a sweet-tempered and silent acquiescence in wrongs. Our second object is to arrest the attention of all those whose common influence or authority has imposed upon geology the disabilities under which it suffers in some of our collegiate institutions. In doing this, we desire to protest not only against the unjust estimate which traditional opinion places on the natural sciences, and in particular on biology and geology, but also and emphatically against the principle that *those departments are to be most fostered which bring most reveuue to the college or university, and are held in hightest popular esteem.* For the very reason that some studies and disciplines look toward professional and money getting ends, they are the better able to take care of themselves. If any study or department has the right to expect special favor and special sustenance, it is a study or department which is purely cultural, occupying a place quite above the level of common appreciation.

We have written thus far as if acquiescing in the arrogant estimate which consigns geology to an inferior and unessential place in a liberal education, and fails to recognize it as potent factor in modern civilization. That it is such a factor, however, is known to the intelligent public, and it is not our purpose to demonstrate it. Geology, in truth, if placed on the basis of usefulness to man, would hold a position in educational processes not inferior to that of literature and languages. In the esteem of the intelligent public it is making rapid and constant advance.

The dissatisfaction of this public with the position of biology and geology in the schools is plainly expressed in such movements as that of the "Agassiz Association" with its seven thousand members, and "Chatauqua Scientific Circle" with its thirty or forty thousand readers and students. We feel sure that public opinion will ultimately compel our moss-grown, conservative educators to admit geology in some of its aspects into the secondary, and even the primary schools, and will revolutionize the collegiate control which persists in consigning geology to an insignificant position. This result, however will be reached through instrumentalities; and we have hoped such an undisguised statement as here made may contribute something to the much needed reform.

We beg to disclaim all hostility to the true interests of any department of learning; for there is no learning in which we do not feel deep concern. We desire only to rebuke the assumption of some forms of traditional learning, and protest against a policy in university control which sanctions their arrogance and helps them to rob certain other departments of their equitable standing and material support.

IRVING AND CHAMBERLIN ON THE LAKE SUPERIOR SANDSTONES.

That perennial source of discussion, the age of the lake Superior sandstones and trap-rocks, has recently been revived by the contributions of Profs. Chamberlin and Irving to the literature of the United States geological survey. In bulletin No. 23[1] they have given an elaborate description and discussion of the geology of points that are considered by them as crucial, situated on Keweenaw point, Michigan. They describe the contact of the trap and sandstone formation with the "eastern sandstones" at Bête Grise bay, at Wall ravine, at St. Louis ravine, at Douglass Houghton ravine, at the Torch lake quarry, at Hungarian ravine, and at other points. They also review and discuss, sometimes with ideal representations of the stratigraphic

[1] Observations on the junction between the eastern sandstone and the Keweenaw series, on Keweenaw point, lake Superior. By R. D. Irving and T. C. Chamberlin.

situation, the various views that have been expressed by geologists since the examination and report of Dr. C. T. Jackson in 1848. They arrive at the final result and state their conclusion thus: "That the Keweenaw series is much older than the eastern (Potsdam) sandstone; that it was upturned, faulted along the escarpment, and much eroded before the deposition of the eastern sandstone; that the latter was laid down unconformably against and upon the former, and that subsequently minor faulting along the old line ensued, disturbing the contact edge of the sandstone."

The description of the shore line of the Bête Grise bay accords with that given by former observers, in all the essential particulars. The eastern sandstone contains some bands of red shale and red pebbly conglomerate. The chief point to note here in discriminating the evidence for and against the greater age of the trap and conglomerate series, is the fact that J. W. Foster in 1849 makes the brick-red pebbly conglomerate identical with some seen on the northern slope of Keweenaw point, and hence of the age of the copper-bearing series. He distinctly states that the eastern sandstone "abuts against a bed of brick-red conglomerate;" this fact goes to show, if a fact, that the sandstone interbedded and conformable with this pebbly conglomerate, is not a part of the eastern sandstone of the region; and that no conclusions, touching that sandstone, can be based upon its relations to the trap and melaphyr. Mr. Foster also states that the high southern dip along the shore of this bay is due to an anticlinal formed by the forcible ejection of the trap rock through a fissure of the earlier sandstone.

However, Messrs. Irving and Chamberlin seem to show satisfactorily, by the pebbles of melaphyr contained in the pebbly conglomerate, both that the conglomerate is unconformable on the trap rock, and that all the light-colored sandstone seen here is of the same age as the red and pebbly beds. The prevailing dip being to the south, and away from the melaphyr and diabase hills lying further north, the natural conclusion is that the sandstone is of later date than the melaphyr and diabase.

At the Wall ravine however, is a series of facts, as illustrated by Messrs. Irving and Chamberlin, which require on their face, exactly the reverse interpretation. This locality is

not far from the Calumet and Hecla mines. Here the horizontal eastern sandstones are represented as turned curvingly upward, and on their approach to the rocks of the Keweenaw series, to assume verticality, and in that position to be unconformably overlain by porphyry conglomerate and diabase belonging to the Keweenawan rocks, the latter dipping northwestwardly at an angle of about 42°. They are separated by a mass of breccia and decayed rock, which has a thickness of about twelve feet.

About a mile south from the Wall ravine is the St. Louis ravine. The same structural features are here repeated. The dip of the Keweenawan rocks, consisting of felsitic conglomerate, amygdaloid and diabase, is 47° toward the northwest. "The sandstone at the junction, and its included bed of conglomerate, dip toward, or beneath, the Keweenawan rocks, at an angle of about 70°, striking with the face of the hill, or N. 40° to 42° E. These measurements were made on the junction between the sandstone and an included conglomerate layer, so that no room is made for doubt as to their correctness." (p. 28.) This plunging of the sandstones beneath the trap rocks, is said by the authors to be due, however, to an overturn dip in the sandstones, by which they conceive them to turn back beneath the surface at a great depth, passing through verticality to a high dip in the opposite direction, then to a low dip, and then to near horizontality. This rather remarkable interpretation is said to be substantiated by exposures of vertical beds of sandrock in the bluffs of the ravine at several points below the place of contact.

Again in the Douglass Houghton ravine the same combination of stratigraphic phenomena appears. This ravine has been examined by J. W. Foster at different times. He regarded the eastern sandstone as more recent than the diabase and amygdaloid and conformable upon them, upheaved by the igneous force that produced the outflow of eruptive rock. Mr. Alexander Agassiz in 1867 discredited the view of Foster and Whitney and showed that the eastern sandstone is unconformable upon the trap rock of the Keweenaw range. Prof R. Pumpelly in 1870-72 adopts the view of Prof Agassiz, but rejects especially the idea of a fault or dislocation which some earlier geologists

had suggested running along the south side of the range, coincident with the line of contact. He regarded the eastern sandstones as quite distinct from and more recent than those that are conformable above the Cupriferous series on the west slope of Keweenaw point. Dr. M. E. Wadsworth, in 1879, made independent and thorough observations in the gorge below the falls of the Douglass Houghton ravine from whieh he came to the conclusion that the beds of the eastern sandstone seen in this ravine pass below the trap and melaphyr beds of the Cupriferous series, although they also embrace beds of conglomerate and of diabase which are identical with some of the beds below which they run. He therefore announced that the "eastern sandstones" are of the same age as the Cupriferous series, and that at this point there is no unconformable position of one series of beds over the other. At the time of Mr. Irving's first examination (1880) he seems to have been in doubt whether the eastern sandstones, seen in the Douglass Houghton ravine were a part of the Keweenaw series or part of the eastern sandstone; yet in his published opinion[1] of the same year he vigorously attacks the conclusions of Mr. Wadsworth, and claims that the sandstone outcrops examined by Wadsworth were a part of the Keweenaw series, and that a considerable interval which Wadsworth must have "bridged over in his imagination," entervenes between these beds and the true eastern sandstone strata further east which lie nearly horizontal. Dr. C. Rominger in 1883, considers the beds described by Wadsworth "as making a part of the copper-rock group, although, considering their lithological character alone I would have united them with the eastern sandstone." He says that they "dip in conformity with the overlying diabase belts." This criticism Mr. Wadsworth answers by reaffirming his former statement, and that by digging in the banks of the stream he actually traced the relations of this sandstone all the way from where it dipped in conformity with the Cupriferous series down the ravine continuously to where the dip had subsided to five degrees. The pebbles and boulders that are referable to the Keweenaw eruptive rocks, seen in the sandstones and their associated conglomerates, appealed to by Irving to prove the prior

[1] Monographs of the United States geological survey; vol. v, p. 355.

existence of the eruptives, Mr. Wadsworth supposes to have been obtained, not from the beds of diabase and amygdaloid seen now in the upper part of the cliff, which has been imagined to have been an ancient shore line which precipitated its debris along the shore and incorporated the fragments from the bluff into the forming sediments of the water, but from some older trap outflows, not seen now in outcrop at this place, but which once were uncovered and perhaps extended over large areas of that region—trap beds which extend, presumably, intact underneath the bed of Douglass Houghton ravine and also underneath the whole of the Keweenaw peninsula. In bulletin No. 23, however, Messrs. Irving and Chamberlin have abandoned the view of Irving in 1880 and have adopted that of Wadsworth so far as relates to the identiy of the north dipping sandstones that pass below the Keweenaw beds, and the horizontal sandstones that appear further down the ravine. They affirm however, contrary to the testimony of Mr. Wadsworth, that these beds at no place are intercalated with beds of trap, and afford no evidence, except that of passing below the trap, of being older than it, which evidence, they say, is illusory.

About a mile southeast from the Douglass Houghton ravine is the Torch lake quarry, where the quarried beds are only 28 feet lower than the top of the Douglass Houghton fall, thus lying high enough to be embraced in the Keweenaw rocks, and if not so embraced then necessarily unconformable upon those rocks. The evidence is not conclusive. No trap rock is described as in contact with the beds. Mr. Wadsworth has inferred, from the dip of the layers of coarser material, and the direction of clay masses, that the dip is toward the northwest about 45°, and that the apparent horizontal bedding is caused by a secondary system of horizontal joints. He therefore considers this rock as a conformable constituent portion of the Keweenaw rocks. Messrs. Irving and Chamberlin reëxamined the quarry together, and they concluded that the rock is essentially horizontal. The lines of sedimentation seen by Wadsworth they regard as a false bedding such as is common in the eastern sandstone. The evidence of the facts, whatever they may be, touching this quarry has only an indirect bearing on the subject of the investigation. If the rock dips northwest it is in conformity with the idea of the

uniformity and entirety in one formation, of all the sandstones, traps, and amygdaloids of the Keweenaw peninsula. If it be horizontal it may be a part of the eastern sandstones, unconformable on the trap rocks, and would be almost confirmatory of the idea of the younger date of the eastern sandstones.

Nearly two miles still further southeast is Hungarian river. At this place, again, the same combination of circumstances conspires with the evident interpretation, and gives a very strong impression that the eastern sandstones run conformably below the tilted beds of the Cupriferous series. This is the natural and most ready interpretation of the facts, if the interpretation be based solely on the evidences here apparent. Messrs. Irving and Chamberlin again claim that the appearances are illusory. They made thorough examination, with the aid of a force of miners, digging several trenches which uncovered the beds that were supposed to form the contact plane of the two formations. In every case they found the eastern sandstone passing northwestwardly below the trap and amygdaloid of the copper-bearing series; but they found evidence that convinced them that it was not conformable to the overlying rocks. Following is the section exposed by the trenches, in descending order.

Section on the Hungarian river.

1. Broken trap essentially in place..........................	10 ft.
2. Trap debris: This follows the other without any definite demarkation or discernible amygdaloid. It seems to be formed of disintegrated trap rubbed into a lumpy clay and roughly laminated. It inclines northwesterly at an angle of about 35°	1 ft. 6 in
3. Red shaly clay: This is a fine textured clay, much resembling what is known as joint clay. It is marked with light grayish-green spots, and has some sandy seams, with occasional lumps of trap. It is only in these latter particulars that it differs from a true joint clay................	6 in
4. Trap debris, similar to that above described, except that it is more mingled with non-trappean (shaly) material. It is dark colored, and so contrasts with the adjoining red clay.	6 in
5. Mixed shaly trap debris and red clay, with a minor element of sand; the whole of a reddish cast................	8 in
6. Light reddish-tinted quartzose sandstone, exposed about..	2 ft.

"On the immediate face of this sandstone (No. 6) at its junction with the trap debris above it, the structure planes—

which may or may not be the deposition planes, so far as we were able to determine—correspond in the main to the oblique contact face." Away from this immediate face, however, they found the same rock dipping northeast, and also lying horizontal. In the general section which is given to illustrate the situation on this stream the sandstones are represented as having an undulating nearly horizontal position, and near the contact as being suddenly bent downward toward the northwest and so passing under the trap beds, which are shown to dip toward the northwest at an angle of about 35°.

Mr. Wadsworth has again visited this place and made further examination, the result of which he has given in *Science* for Sept. 30, 1887. He says "we were able to trace continuously the unchanged eastern sandstone into the sandstone which has been baked and indurated by the old lava-flow, and this baked sandstone into the lava-flow or melaphyr itself, all forming a continuous exposed surface. There is no fault, or plane of separation between the sandstone and the trap, but the two are welded together into one mass. * * * * The contact is that made by a lava-flow with an underlying sandstone, and is the same as the contacts so often seen within the copper-bearing series, while the sandstone is observed *in situ* to pass underneath the melaphyr."

The authors review all previous opinions, and give their objections to them.

The Jackson view, so named from C. T. Jackson its author, is stated in four propositions. (1). The eastern sandstones and the conglomerates and sandstones of the copper-bearing series are one and the same formation, and were once spread out continuously in a horizontal position. (2). The traps of the copper-bearing series are all of them intrusive, having invaded the supposed sandstone formation in part as irregular intersecting masses, and in part in the shape of sheets which forced their way between the sandstone layers. (3). The conglomerates of the copper-bearing series derived their material by the ordinary aqueous agencies from some subjacent formation, which possibly may have formed an old shore line in the immediate vicinity of Keweenaw point. More probably, however, the pebbles of the conglomerate have been sorted out, as it were, from the pre-

viously existing sand beds, by the violent currents set in motion at the time of the trappean intrusions. (4). The inclination *southeastward* in the eastern sandstone at the junction with the traps, and that to the *northwestward* of the sandstones and conglomerates of the copper-bearing series, are due to the intruding trap. This view is discarded because the contemporaneous, or lava-flow origin of the traps has been repeatedly and abundantly demonstrated.

The Foster and Whitney view, as summarized, contains six propositions. (1). The eastern sandstones and the Keweenaw detrital rocks are one and the same formation. (2). The associated igneous rocks are of two classes: (a) Traps that are interleaved with the detrital rocks, of lava-flow origin, (b) the traps of the Bohemian range, which are held to not be bedded but massive and intrusive, and of later origin than the detrital rocks and their interbedded traps. (3). This later eruption of trap was the cause of the tilting of the bedded traps on the north side toward the northwest, and the sandstones on the southerly side toward the southeast, and of the production of "jasper" masses by a change of the detrital rocks. (4) The conglomerates of the trappean series are mainly of igneous origin, the rounding of the pebbles being due, not to water action, but to friction of the elevated rock against the walls of the fissures. To the production of these conglomerates, by eruptive agencies is to be attributed the immensely increased thickness of the detrital portions of the formation in the region of Keweenaw point. (5). The various bedded eruptives of Keweenaw point reached the surface through a series of fissures along the course of the point. (6). The massive trap of the Bohemian range was extruded through an immense fissure which extended as far west as Gogebic lake; running along the southern edge of what is now the trappean formation; but along its western extension this fissure was not accompanied by any igneous outflow, thus allowing the sandstones of the northwest to come immediately against the eastern sandstones.

The first of these propositions the authors think is not sustained by results of microscopic examinations they have made of thin sections of these two sandstones. They find the eastern sandstone always much more quartzose and the grains much

more rounded, and more likely to be destitute of detritus from eruptive rocks.

The division of the eruptives into two classes they think is not warranted. The so-called massive trap of the Bohemian range is itself bedded, and even contains interstratified conglomerates.

The dip of the eastern sandstones toward the southeast is not due, in the opinion of the authors, to the extrusion of the Bohemian range; for this dip is found not only at the contact but at points beyond the possible reach of such extrusion.

The so-called jaspers are of the same nature as the quartz porphyries and felsytes of the Keweenaw rocks, and these are regarded as acid eruptives within the rocks of that series. They could not hence have been caused by any metamorphism of the sedimentary beds produced by the eruptive rocks of the Bohemian range. They were, further, the source of the pebbles of the Keweenaw conglomerates, and must, therefore, on the hypothesis of Messrs. Foster and Whitney, have antedated the Bohemian disturbance.

The series of fissures which gave vent to the trap of the Keweenaw rocks are supposed not to have been along the course of Kewenaw point, but quite to the southward, and they are now probably buried by the newer sandstones.

They accept, however, number 6 of the propositions of the Foster and Whitney view, but they qualify it by two exceptions; (a), that the fissure was not formed subsequent to the production of the eastern sandstone, and (b), when formed it did not give vent to any eruptive material. These exceptions are necessary because the sandstones on the opposite sides of the Bohemian range do not seem to have been faulted away from each other and if they had been the enormous downthrow of 35,000 feet would be required to explain their present relative positions; also because at points east of lake Gogebic the lowermost members of the Keweenaw series, dipping northward, are found to be overlapped in unconformable position by the eastern sandstone.

The Agassiz view regards the south face of the the trap range of Keweenaw point as an ancient shore cliff, having been produced entirely by the erosion of the waves of that sea in which the

eastern sandstone was laid down. It also supposes that the Keweenaw series extends unconformably continuously beneath the eastern sandstone to the "south range," the entire trough in which this sandstone lies having been produced by erosion. To this view the authors object because it necessitates an inconceivably great thickness for the Keweenaw series, and an enormously great erosion prior to the deposition of the sandstone. With modifications, however, this view is adopted by the authors. They remove both of the difficulties by supposing the south face of the trap range to have been in the first place the result of faulting.

The Rominger view. According to Dr. C. Rominger the eastern sandstone was once extended conformably over Keweenaw point, and the sandstones that now are seen at the mouth of the Portage canal near the lake shore, while belonging to the copper-bearing series, approach the eastern sandstone so closely in character that they may be considered as the lower portions of that formation. According to this view the Keweenaw rocks are older than the eastern sandstones, but on the western slope, and perhaps at other places, pass upwardly into the eastern sandstone conformably; while on the eastern side, owing to the production of a fault during the accumulation of the sediments of the eastern sandstone, running along the east side of the trap range, the later sediments of this sandstone are locally unconformable on the trap rocks.

In rejecting this view the authors cite specifically several places where the horizontal sandstones lie unconformably on the upturned edges of the Keweenaw series, viz.: in the St. Croix region, in the Gogebic region and in the region north of the Montreal. Further, they do not admit the similarity between the sandstone at the mouth of the Portage canal and the eastern sandstone. Still they do not state wherein the unconformabilities to which they refer differ from that which Dr Rominger admits on Kewenaw point, and to which he refers for proof of the correctness of his view. The authors also refer loosely to the "Potsdam sandstone," and they confound the beds that lie on the trap at St. Croix falls with the eastern horizontal sandstone which they are discussing. They also assume that the trap seen at the St. Croix falls is the equivalent of that embraced in the

Keweenaw rocks, and of this presumed equivalence there are good reasons for entertaining much doubt.

The Credner view conceives of the eastern sandstones, the traps and conglomerates of Keweenaw point, and the sandstones on the west side of the point, as constituting one conformable series of strata, the sandstones on the east passing below the principal mass of the trappean rocks, and those on the west lying conformably above them. In this view the sandstones are not of the same age, and the eastern sandstone is the older. This view is substantially that which is held by Dr. M. E. Wadsworth.

This requires in the opinion of Messrs. Irving and Chamberlin, an incredibly great amount of denudation to account for the non-extension of the trappean beds toward the south and east of Keweenaw point. They show, by a diagram drawn to a scale, that when these beds were intact, on this hypothesis, they must have had a thickness on Keweenaw point, in addition to their present perpendicular altitude, of about four miles. They may have stopped there in an imagined perpendicular cliff, or they may have been extended conformably eastward over the lower strata of the eastern sandstone. The latter alternative is accepted by the authors as the only reasonable one, and then they find insuperable difficulties in the way of the Credner view. These consist in the entire absence of these strata toward the southeastward where this alternative would require them, and the existence of the "singularly abrupt linear, often cliffy, southern limit of the trappean series." Another difficulty is the fact that the eastern sandstone graduates upward, a few miles away from Keweenaw point, not into the Keweenaw rocks, but into the Calciferous sandstone, and that the Trenton limestone, even, is seen probably in its true stratigraphic position (above the Calciferous) in the same region; "it is a heavy strain on our credulity to ask us to place the great Keweenaw series in this interval." The evidence which Mr. Wadsworth has presented to show the correctness of this view consists of four postulates. (1) The eastern sandstone passes conformably beneath the trappean series, (2) as it approaches the Keweenaw range it is interstatified with rocks identical with those that make the bulk of that range, (3) it shows an induration due to heat from trap

overflows, similar to what is common in the Keweenaw rocks, and, (4) it does not contain, except sparingly, fragments derived from the trappean series, and no more than can be referred to the slow accumulating action of waters in the production of a conglomerate from distant sources. These are severally set aside as invalid because based on incorrect observation. There is a surprising contrariety between the observations and conclusions of Mr. Wadsworth and those of Messrs. Irving and Chamberlin. "In the Wall ravine, the eastern sandstone, instead of dipping beneath the Keweenaw beds as demanded by this hypothesis, shoots upward toward the zenith. * * * In the St. Louis ravine the beds are likewise turned skyward near the contact, and at a short distance away they dip at lower inclinations, away from the Keweenaw series; * * * in the region back from Ontonagon the eastern sandstone likewise dips away from the Keweenaw series near the contact. * * * and in none of these localities is there any approach to a conformity with the hypothesis of Credner and Wadsworth." Even at the points which specifically were examined and described by Dr. Wadsworth, viz.: in the Douglass Houghton and the Hungarian ravines, "the eastern sandstone, instead of passing conformably beneath the trappean series with a like steady dip, is warped and angulated in a manner altogether inconsistent with the character of the Keweenaw series * * * and is discordant with the beds of the Keweenaw series." The bending downward of the eastern sandstone at the point of contact, in approximate conformity with the overhanging Keweenaw beds, they regard as one of "the several phases of distortion that accompanies the contact of these diverse formations." The supposed interstratification of the two formations is denied in toto, and the induration of the sandstone by heat is "no greater than at points distant from the contact;" and "if such induration were present it would be no proof of heat action." As to the presence of pebbles in the eastern sandstones, referable to the rocks of the Keweenaw series, the authors affirm that they find both acid and basic eruptives in that form, and that there is no other group of rocks known in the entire lake Superior region from which these pebbles could have been derived. It seems to us, however, that the existence of these pebbles in the eastern sandstone allies it with the

recognized Keweenaw sandstones and conglomerates, so far as similarity of composition constitutes a link of alliance between formations, and here it is a strong link, because it is as easy to explain the presence of those in the eastern sandstone, without invoking the presence of a sea-cliff, as it is those in the Keweenaw sandstone itself.

The concluding opinion of the authors, one which satisfies all the conditions of the case, of which they enumerate those of stratigraphic position and composition, and of general topographic relations as brought forward by their discussion, is expressed thus: "That the Keweenaw series is much older than the eastern (Potsdam) sandstone: that it was upturned, faulted along the escarpment, and much eroded before the deposition of the eastern sandstone; that the latter was laid down unconformably against and upon the former, and that subsequently minor faulting along the old line ensued, disturbing the contact edge of the sandstone."

The document is undoubtedly one of the ablest discussions of stratigraphic problems that has ever been produced in America, and it will long remain a monument to the scientific skill and the genius of the authors, *ære perennius*, although it cannot be said to close the discussion by that convincing array of evidence that the importance of the issue demands.

One or two reflections, in conclusion, derived from the foregoing examination of the work, will be warranted at this place.

1. It is a remarkable fact, admitted by the authors, and shown by their diagrams, that the eastern sandstones pass beneath the Keweenaw rocks at places along the south side of the range. Whatever be the true explanation of this fact, first insisted on with detailed description by Dr. M. E. Wadsworth, it brings prominently to mind another "view" to which the document makes no illusion, viz.: that of Houghton, which maintains that the trap-rocks of Keweenaw point, and of the copper-bearing series in general, are not of paleozoic age, but mesozoic, being the equivalent probably of the trap and brown sandstones of Connecticut. In consonance with this view are those facts appealed to by the authors that seem at variance with the Credner view, *i. e.*, the contact of the two formations is not always at the same stratigraphic horizon. There is an oblique over-

lapping which brings different beds into contact at different places.

2. The "joint clay," included in the contact phenomena, embracing some trap and some sandstone debris, can easily be explained by referring it to other source than that of faulting. There would be nothing more likely than that, in case of an overflow of molten rock on sedimentary rocks, with a subsequent tilting of both, there would be, in places, a more rapid decay at the contact plane, owing to the mechanical mingling and consequent difference of grain and texture of the fragments that were caught between the two rocks. This progressive decay will not only account for the confused "clay," but also for the non-differentiated face of the two formations along the contact as described by the authors.

3. The authors assume that the "trap rock," where it is found in the south range, and at Taylor's Falls in the St. Croix valley, is of the same age as that seen on Keweenaw point. This is a weak point in their argument, for it is not only not proven, but it is, in our opinion, open to serious doubt. There is much reason to regard the Taylor's Falls trap of a much earlier date than that of the copper-bearing rocks on Keweenaw point.

4. The authors assume that the horizontal sandstones that lie unconformably on, or run over or below the Keweenaw trap, whether found on Keweenaw point or in the St. Croix valley, are everywhere of the same age. This is not only questionable, but it is demonstrably incorrect. Two different sandstones are here confounded—sandstones which have been distinguished before by both of the authors as separate and distinct.

2. The strained interpretation of the facts, given by the authors, throws a shadaw over the credibility of their results. When it is remembered that this explanation was adopted by them several years ago, before the adverse facts which Dr. Wadsworth announced were known, and that they have written extensively, on this hypothesis, the shadow is deepened, and there remains in the mind of the scrutinizing reader, a suspicion that the authors are not disinterested and perhaps not impartial judges of the facts. This is saying nothing more than might be said of any geologist.

6. The question is open still, and wider open than ever before, as to the age of the copper-bearing rocks of lake Superior.

REVIEW OF RECENT LITERATURE.

Geological Survey of the State of New York, Palæontology, vol. vi. Corals and Bryozoa: Text and Plates, containing Descriptions and Figures of Species from the Lower Helderberg, Upper Helderberg and Hamilton Groups. By James Hall, State Geologist and Palæontologist, assisted by George B. Simpson. Albany, 1887.

Of the many valuable, recent contributions to the literature of palæontology, none probably will occupy a higher place in the regard of palæontologists, or receive from them a warmer welcome, than the volume above cited. This volume deals with the corals and bryozoa of the Lower Helderberg, and the bryozoa of the upper Helderberg and Hamilton groups. The dedicatory letter of the author to Gov. Hill of New York bears date, August, 1887. The text includes pages xxvi—298, and the volume is illustrated by plates 1—lxvi.

Only a small space in the volume before us is devoted to corals. By far the larger portion is given to the bryozoa--a group that though represented abundantly in the fossil faunas, has hitherto been confessedly among the most difficult of all that fall within the province of the working palæontologist. The meagerness of the literature on the subject has caused the bryozoa generally to be neglected by the amateur student and collector. Both to the amateur and the professional palæontologist therefore, this volume will be particularly welcome.

The volume, in the preparation of the text as well as in the generic and specific determinations of the great number of forms therein described, bears evidence of the painstaking care and scientific skill that have given value and character to the preceding volumes of this magnificent series. Indeed the eminent name that appears on the title-page will be, to palæontologists at home and abroad, a sufficient guaranty that the scientific part of the work has been skilfully and conscientiously performed. When it is said that nearly all the drawings were made by Mr. G. B. Simpson, nothing more will be needed to commend the plates for beauty and faithfulness of delineation to persons familiar with the work of this artist.

Pages xi—xxvi are occupied by a synopsis of the genera included in the volume. This synopsis has been prepared by Mr. Charles E. Beecher, and will add greatly to the value of the work to the experienced palæontologist as well as to the amateur student.

Zoölogists generally will probably regret that the term *polyzoa* had not been used in this volume instead of *bryozoa*. The term, *bryozoa*, certainly has no standing in modern zoölogical literature. Huxley, Allman, E. Rey Lankester, Gegenbaum, Packard, and all the list of zoölogical writers recognize the priority of the name given by Thompson in 1830 over that applied by Ehrenberg in 1834. Geologists and palæontologists for some unaccountable reason adhere to the name proposed by Ehren-

berg. Probably Nicholson may be cited as an exception, but Nicholson is also a zoölogist in the modern sense, and this may be accepted as a sufficient explanation of his position respecting the use of these conflicting terms.

There are a few errors that have been overlooked in compiling the list of "errata." By some jugglery of the engraver and printer the family names at the head of plates i and vi have exchanged places. It is something of a surprise to find on plate I *Streptelasma* and *Zaphrentis* ranged under the head of *Favositidæ* — a form of surprise that is repeated when we find, on plate iv, a number of specimens of our old acquaintance, *Favosites helderbergiæ* Hall, masquerading under the family name of *Cyathophyllidæ*. In the description of plate xvi, the generic name *Ceramopora* has lost an o, and becomes, through another bit of crookedness on the part of the printer, *Cerampora*. On the whole, however, mistakes of proof-reading, or of any other sort, are exceptionally few, Palæontologists will have occasion chiefly to regret the limitations as to size under which the volume was prepared, making it impossible to include all the forms now known from American strata of the age of the Upper Helderberg and Hamilton periods.

On the monticuliporoid corals of the Cincinnati group, with a critical revision of the species. By U. P. and JOSEPH F. JAMES. (From the proceedings of the Cincinnati Society of Natural History, October, 1887.) "The group of fossils known under the general name of monticuliporoids represents a wonderfully diversified series of forms. Not many years ago they were considered too obscure and too difficult for the ordinary student, and collectors, as a rule, paid little attention to them. One of us was among the first to call attention to them, and in 1871 issued a catalogue of the fossils of the Cincinnati group, the first of its kind, in which were named provisionally a few new species. A second edition of the catalogue was published in 1875, and here two of the previously named species, and two new ones were described. In the same year the second volume of the *Ohio Palæontology* was issued, and in this professor H. Alleyne Nicholson described and figured a number of species under the generic name *Chætetes*, adopting some of the names proposed in the catalogue of 1871. Between 1875 and 1881 were issued various papers or volumes containing descriptions of other new species, and in the latter year was published a monograph on the genus *Monticulipora* by Prof. Nicholson. In this volume, by far the most valuable account of these fossils that has yet appeared, we have chapters giving the general history of *Monticulipora* and its allies, an account of the general structure of the genus and its development, a division of the genus into five sub-genera, with the characters of each, and detailed descriptions, with figures, of forty-three species, thirty-three of which are found in the immediate vicinity of Cincinnati. Finally Mr. E. O. Ulrich, began in 1882, in the fifth volume of the Journal of the Cincinnati Society of Natural History, a series of articles entitled 'American Palæozoic Bryozoa,' which was continued through the sixth and into the seventh volume, 1884. Mr. Ulrich

considered the monticuliporoids as bryozoa, instead of corals, and in the course of his investigations divided and sub-divided the old genus *Monticulipora* into a multitude, no less than eighteen different genera. At the same time a host of species were described, most of them from internal characters, and they were illustrated by a profusion of drawings of the internal microscopic structure. Our opinion of this vast array of genera and species, and of microscopic work of this sort in general, will be given in detail later on in the present paper, but we cannot forbear saying that it is our belief that this work has resulted disastrously to the study of a confessedly difficult class of fossils; making it more difficult and confusing than ever before, and loading it with a mass of synonyms which of themselves are enough to deter one who should so desire, entering upon the study. The cause of this we believe to be an erroneous method of study, and we ascribe the vast number of species and genera made to the almost exclusive attention given to microscopic characters."

The authors discard all the genera that have been described by Nicholson and Ulrich, and place known forms under two genera, *Monticulipora* D'Orb, and *Ceramopora* Hall. Under the former they allow the sub-genera *Dekayia* Ed. and H., *Constellaria* Dana, and *Fistulipora* McCoy. These distinctions are based on external characters of form and habit. They object to the use of internal characters in determining species and genera, "because they entail an immense amount of work which in the end seems to amount to very little." They also consider the internal characters more variable and unsatisfactory than the external. They allow, however, that "there is, in fact, no criterion by which to judge fossil species, except individual opinion." We should be sorry to see any minute research with the aid of the microscope, into the internal structure of fossils, discountenanced and retarded because of the difficulty of the work. There may be, and doubtless have been, more species created on paper than actually exist in nature. As to the value of the differences that any investigator may discover, he is likely to over-estimate it. But it is very doubtful whether such differences would be searched out and recorded if the investigator did not himself feel satisfied of their importance, be they external or internal. His record of them, while it multiplies species, is the most effective record, and is, of itself, no detriment to the progress of science - but rather an aid. There is, as yet, no accepted limit nor limitation to an organic species, and there is no restriction to the use of individual opinion. Ultimately perhaps some biological principles may be established by which species may be defined. When such is the case they may be applied to the elimination of some of the specific names, or to the recognition of much finer and more numerous distinctions.

A spiral bivalve shell from the Waverly group of Pennsylvania. By CHARLES E. BEECHER. (From the thirty-ninth annual report of the New York State Museum.) Mr. Beecher describes and figures a new genus and species, *Spirodomus insignis*, of boring molluscs, from what he con-

siders the marginal shore-line strata of the Waverly, found in Warren county, Pennsylvania.

The summit plates in blastoids, crinoids, and cystids, and their morphological relations. By CHARLES WACHSMUTH, and FRANK SPRINGER. (From the proceedings of the Academy of Natural Sciences, Philadelphia. March, 1887.) The authors take issue with Etheridge and Carpenter, of the British Museum, in their catalogue of the blastoidea, in their statement that these plates do not, as a rule, present any very definite arrangement, though they exhibit a series of variations in number and position in some degree corresponding to similar variations in the palæocrinoidea, and that they vary from five closely united plates, fully covering the summit, to a set of six proximal plates surrounding a central one. Such a variation. from five closely fitting plates to six or more around another the authors do not consider established by the evidence that is adduced.

The morphology of the carinæ upon the septa of rugose corals; sixteen plates. By MARY E. HOLMES, A. M. (Presented as a thesis for the degree of doctor of philosophy in the University of Michigan, June, 1887.) This article, which reveals in a lucid manner the minute, discriminating though quiet work done in the palæontological department of the University of Michigan, comes to the conclusion that the carinæ are not aggregations of crystals,—mineralized surface decorations—but, in substance and structure, are homogeneous with the coral itself, are normal outgrowths from the septa, and not homologous with any of the usually recognized structures; also that they had functional value in the animals themselves, even where the vesicular tissue is almost wholly wanting.

Description of primordial fossils from Mt. Stephens, N. W. Territory of Canada. By DR. C. ROMINGER. (From the proceedings of the Academy of Natural Sciences of Philadelphia, 1887.) This new locality of primordial fossils furnishes the following species: *Ogygia Klotzi* and *O. serrata*, both new forms; also *Embolimus spinosa*, and *E. rotundata*, new forms; also *Menocephalus salteri* Billings, *Conocephalites cordilleræ* (new), *Bathyurus*, *Agnostus*, *Obolella* and a *Theca* resembling *T. primordialis* Hall.

Untersuchungen ueber Gesteine und Mineralien aus West Indien. Von DR. J. H. KLOOS (Sammlungen des geologischen reichs Museums in Leiden, December, 1886). Dr. Kloos describes a new calcium-phosphate which he names martinite, obtained by Prof. Martin on the island of Curacoa. It was found as a pseudomorph after gypsum. From the island of Aruba he describes among the massive diorytes, quartz-dioryte, augite-dioryte and gabbro, porphyritic dioryte and dioryte-porphyry, and mikrocline-granite. From the region schists he describes some subcrystalline sedimentaries and diabase, porphyritic rocks, and some schistose amphibole-bearing rocks. These rocks are entirely different, according to Dr. Kloos, from any that have before been brought from the islands of Aruba and Curacoa, constituting in the western part of Bonaire, mountain ranges. He considers it likely, though not proven by any certain evidence, that the eruptive rocks are younger than the sedimentary strata of the island of Curacoa, which are of Cretaceous age

Preliminary report upon petroleum and inflammable gas. By EDWARD ORTON, State geologist of Ohio. (A publication of the Ohio geological survey.) This is a valuable compend of the principal facts relating to the gas and oil supply of Ohio. In November, 1884, high-presure gas was discovered at the depth of about 1100 feet at Findlay, in Hancock county. The surface signs of gas had been very well known for many years, and some enterprising gentlemen had devised plans for making use of it by collecting it and lighting their residences, but its source had not been discovered, nor even conjectured. It was a complete geological surprise to find the Trenton limestone which nowhere rises to the surface in Ohio, a source of gas, and later of oil, in large amount and great value. The success at Findlay produced a widespread expectation that the Trenton limestone was gas-bearing everywhere throughout the state, and a great many wells were drilled to it, and into it, without success, the most of them being about 1200 feet deep. This expectation has not been verified. But a small proportion of the wells that have been drilled have proved productive. Findlay, Bowling Green, and Lima, respectively in Hancock, Wood and Allen counties in the N. W. part of the state were the fortunate points where success had been met with. Prof. Orton describes other geological horizons at which gas has been found in Ohio, viz. the Ohio shale, the Berea grit, the Clinton, Medina, Hudson river and Utica shales and the glacial drift, and concludes with the statement that natural gas is one of the common and widely distributed substances in nature, and a little of it at least can be found anywhere. This brochure is filled with important practical statements of facts and principles that bear directly on the origin, consumption, nature and discovery of gas in Ohio; and its value to the State, if it be properly distributed and heeded, will be more than the entire cost, great as it is, which the survey has been to the State from its inception to the present time. It is one of the most practical exemplifications of the value of a geological survey in such emergences as the late fever on gas and oil which spread over northwestern Ohio. This preliminary report is to be followed by a complete exposition of the whole subject, in the light of later developments.

Some of the general principles stated by Prof. Orton are as follows:

Petroleum, which is the necessary preliminary to the existence of gas, is derived from vegetable, or vegetable and animal substances that were deposited in, or associated with, the forming rocks.

Petroleum is not in any sense a product of destructive distillation, but is the result of a peculiar chemical decomposition by which organic matter passes at once into this or allied products. It is the result of the primary decomposition of organic matter.

The organic matter still contained in the rocks can be converted into gas and oil by destructive distillation, but so far as we know in no other way. It is not capable of furnishing any new supply of petroleum under normal conditions.

Petroleum is in the main contemporaneous with the rocks that con-

tain it. It was formed at or about the time that these strata were deposited.

In order that there may be a supply of gas or oil from any drilled well it is necessary that three geological facts must co-exist at that place. (1) A producing source of oil or gas in the form of a stratum charged with organic matter. (2) An overlying reservoir in the form of a porous sandstone or limestone, and (3) an impervious, fine-grained rock or cover. A fourth element seems also necessary, at least in the high-pressure wells; viz., an anticlinal fold in the underlying strata, as pointed out by Prof. I. C. White.

At Findlay the gas is essentially light carburetted hydrogen, or marsh gas, but with small quantities of hydrogen and nitrogen, and its heating quality greatly exceeds that of the present Pittsburg supply. Its natural pressure is about 375 lbs. to the square inch. In the spring of 1886 there was a daily waste, for several months, of at least 16,000,000 cubic feet of gas at the Findlay wells. The flow of gas sometimes diminishes and is then accompanied, especially at Lima, by petroleum, or by petroleum and brine.

The lake-age in Ohio; or some episodes during the retreat of the North American ice-sheet. By PROF. E. W. CLAYPOLE, of Buchtel College, Akron, O. (Mc Lachlan & Co., Edinburgh; Robert Clark & Co., Cincinnati.) The former existence of a great ice-sheet over the midland region of North America has now passed beyond the domain of speculation and is one of the admitted facts in American geology. The above named paper is an attempt to trace the series of changes which must have followed the retreating ice. It is divided into three parts, the first of which considers the condition of the Ohio and the adjacent country at the time of the greatest extension of the glacier. The various lines of evidence brought forward during recent years are considered and the inferential geographical changes are detailed. In the author's opinion the valley of the Ohio was occupied for many years by a great body of water, "lake Ohio," the approximate outline of which is traced and its probable history sketched. The causes and the mode of its disappearance are touched upon and tbe traces which it left upon the country are stated.

The second stage in the story commences when the retreat of the ice had carried it so far north that the whole southern portion of Ohio was uncovered and the ice-front had receded to the northern slope of the water-shed of the state. When it occupied this position it completely blocked the outflow of all the rivers flowing in that direction. There were consequently formed a multitude of little glacial lakes or ponds held in by the ice until they overflowed to the southward, forming as many streams whose waters ultimately found their way into the Ohio river. The life history of one of these lakelets is traced in full as an example of what the others must have been. This is "lake Cuyahoga," formed in the valley of that river between Akron and Cleveland. The overflow of this was through the gap in which Summit lake and the

Ohio canal now lie, and the water passing by this channel reached the Tuscarawas and when the Muskingum, on its way to the Ohio. Evidence of the existence of this lake is found in the deposits left in the valley of the river which are described in detail.

The third stage in this story commenced when the ice-sheet had so far retreated as to cause the confluence of all these glacial lakelets and the formation of a single, but much more extensive, sheet of water in their place — the forerunner of the present lake Erie. At this time the edge of the ice was to the north of the lakes and the St. Lawrence, in Canada. The altitude of the surface of this lake and its place of overflow are discussed and its great extent is pointed out. The gradual changes produced by the slow but steady withdrawal of the ice from the face of the country are explained and the results are traced in some detail. The influence of the high and cold area of the Adirondacks in preventing the outflow of the water of this compound "lake Erie-Ontario" and the successive stages whereby the drainage was gradually developed in its present direction along the St. Lawrence valley, are shown.

All these various stages in the evolution of the existing physical geography of the country are illustrated with four colored maps, showing, in as many colors, the extent of the water, the ice and the land, at each successive stage. Of course such representations are and must be only approximate in the present imperfect state of our knowledge of the subject. Full details can only be supplied hereafter.

The work aims merely at being a summary of the present state of our knowledge of this interesting geological study. It groups in a systematic scheme many of the wide-spread evidences that are legible from the drift itself, of the local superficial action of water on the till deposits. It seems to be one of the final steps in the demolition of the oceanic-iceberg-theory as to the origin of the drift; since it explains on the hypothesis of the continental glacier nearly all the anomalous facts that have been advanced in favor of the ice-berg theory. It is one of those reservoirs from which the amateur and teaching geologist can draw important information, which will be needed in the class-room.

The West American Scientist, a popular review and record for America; official organ of the San Diego (California) Society of Natural History. This publication, which is well edited, is in its third volume. Mr. C. R. Orcutt, the editor, is preparing an international scientist's directory for the year 1888.

Bulletin No. 39 of the publications of the United States geological survey, is by Mr. Warren Upham. It gives a preliminary account of the upper beaches and deltas of the glacial lake Agassiz, embracing a profusion of details respecting the position, altitude, and external appearances of these breaches, so far as they exist in Minnesota and Dakota. The beaches that are described are the Herman, the Norcross, the Campbell and the Mc Cauleyville beaches, the highest being the Her-

man beach. When lake Agassiz had this level its outlet was 75 feet above the present level of lake Traverse, in western Minnesota, or 1045 feet above the sea, and its waters followed the present course of the Minnesota and united with the Mississippi river at Fort Snelling. The Norcross beach is 20 feet lower; the Campbell beach 50 feet still lower, and the Mc Cauleyville beach 15 feet still lower. These beaches ascend toward the north, the highest one at much greater rate than the lowest. They also ascend from west to east, since they are traceable continuously from Minnesota into Dakota: but this ascent is low in amount, though diminishing in a similar ratio between the successive stages of the lake. Mr. Upham estimates that when this lake had its greatest extent it was larger than lake Superior, and its depth at the international boundary line, at St. Vincent, Minnesota, was about 450 feet.

Preliminary reports on the Southeastern Kentucky coal field. By A. R. CRANDALL and G. M. HODGE. (One of the publications of the New Geological Survey of Kentucky. Robert Clarke & Co., Cincinnati, authorized agents for the sale of the publications.) This is one of the valuable economic reports of the Kentucky survey. It is illustrated by topographic maps by J. B. Hoeing, and by page-plates showing the surface contours and vegetation at numerous places. It also has 31 page-plates showing rock-sections covering the strata that are coal-bearing. The geological description gives a general account of the Pound Gap region, of the counties of Letcher, Harlan, Leslie, Perry and Breathitt, of the Lower North Fork, the Middle and the South Forks of Kentucky river, with notes on Wolfe and Clay counties. It gives the analysis of numerous Kentucky coals by Dr. R. Peter.

Annual report of the geological survey of Arkansas for 1887. By JOHN C. BRANNER, State geologist. This is purely an administrative report of 15 pages, but it lays out the ground-work from which in the future may be expected very valuable scientific results.

In the American Magazine for December is an illustrated popular article by Mr. Z. L. White. on "natural gas at Findlay." This article is a curiosity of its kind. It illustrates the greed with which reporters and professional writers seize on half-truths, and by the aid of illustration and a lively imagination, construct magizine articles which read well and entertain the subscriber, who may not be able, or who may not care to take the trouble, to verify the statements made. This light entertainment is harmless so long as the writer adheres to the truth, but so soon as his poetic imagination transgresses the requirements of known historic and scientific verity, the diversion becomes nauseating and harmful. To illustrate these remarks it is only necessary to call attention to the fact that many citizens of Findlay, besides Dr. Oesterlin, the "expert geologist and mineralogist," knew of the gas escaping from the crevices of the rocks in the valley of Blanchard creek and through the soil about Findlay, and some of them devised methods of using it for economic purposes; that the gas that escapes from the wells at Findlay is not sulphureted, but carbureted hydrogen; that when the report on Hancock

county, by the Ohio geological survey, was printed it contained an account of this gas, and of successful efforts that had been made to use it, as early as 1838; that although Prof. Orton admits that it was a complete surprise to find the Trenton limestone a source of gas; he also makes the following statement, (which Mr. White could have quoted, and probably would if it had not been likely to spoil a sensational paragraph,) "It has been utilized here in a small way for more than forty years. Prof. Winchell in his report on the geology of the county, in 1872, made mention of the interesting fact that Mr. Jacob Carr had, for a number of years, lighted his home on Main street with gas collected from wells on his premises. * * * Other facts bearing on the gas supply were given by Prof. Winchell. The composition of the gas had been determined for Mr. Carr by Dr. Chilton, of New York, who pronounced it light carbureted hydrogen and derived from petroleum. The first statement gave the result of an approximate analysis, and the second was a sagacious inference." These facts, according to Prof. Orton, are published in the same volume which, according to Mr. White and Dr. Oesterlin, the "expert geologist and mineralogist" of Findlay, contained not a word about the gas at Findlay. Geological surveys are generally not supplied with funds for experimenting in practical tests in advance of expert manufacturers and large consumers. They announce the facts of observation, the probable extent of economic products, and point out possibilities. It seems that the Ohio geological survey did all this, not only announcing the existence of gas in great quantities, but *sagaciously inferred* that it came from petroleum.

PERSONAL AND SCIENTIFIC NEWS.

ON NOVEMBER 18TH THE REGENTS OF THE SMITHSONIAN INSTITUTION elected Prof. S. P. Langley, now president of the American Association for the Advancement of Science, secretary of the institution to succeed the late Prof. S. F. Baird. The scientific predilections of professor Langley are more in keeping with the researches conducted by the lamented Prof. Henry than with those of Prof. Baird, and it is very likely that astronomical and physical research by the institution will be revived with its wonted vigor.

THE UNITED STATES COAST AND GEODETIC SURVEY has been engaged during the summer, through the services of Maj. C. O. Boutelle, assistant in charge of state surveys, in making triangulation in Minnesota. One of the immediate objects of the summer's work, as requested by Prof. Winchell, the state geologist, was the determination of the exact length, width and position of the gorge of the Mississippi river between the falls of St. Anthony and Fort Snelling, to find reliable data for the discussion of the recession of the falls. The work is left in charge of Prof. W. R. Hoag, of the University of Minnesota.

ACCORDING TO PROF. J. S. NEWBERRY, who read a paper on

the subject of gold and silver production at the late meeting of the National Academy of Sciences, the annual production of gold in the United States is already past its maximum. It is now about thirty millions of dollars, that of Europe being about the same.

DR. A. E. FOOTE OF PHILADELPHIA, who has spent the summer in London in attendance at the American Exhibition, will shortly return with a varied and extensive collection of minerals and fossils obtained in different parts of Europe.

EXTINCT PECCARY IN MICHIGAN. In the spring of 1887, the University of Michigan received a quantity of bones of the extinct *Platygonus compressus,* discovered in Ionia county. Examination showed that they represented five individuals, and that of one skeleton nearly all the parts had been preserved. The cranium was complete; there were teeth, 31; vertebræ, complete series, 29; sacrum, second caudal and two innominata, 4; ribs, 27; parts of anterior extremities, 8: of posterior, 26; total, 126 bones. Of a second skeleton, there were 70 bones; of a third, 57; of a fourth, 37; and of a fifth, 4. Grand total, 294. The remains were crowded together in a deposit resembling loess—but whether loess or not, it was not peat, but quite an upland formation, and associated with modified drift. The first skeleton is probably the completest known; and will be fully described and illustrated by professor Alexander Winchell. The four skeletons have been arranged, and are on exhibition in the museum of the University of Michigan.

MR. WARREN UPHAM OF SOMERVILLE, MASS. has completed, for the United States geological survey, the field-work of his examination of lake Agassiz, an ancient body of water that occupied portions of Minnesota, Dakota and Manitoba as one of the incidents of the retreat of the continental glacier. Mr. Upham began this examination for the Minnesota state survey, and has completed it under the auspices of the U. S. and the Canadian surveys.

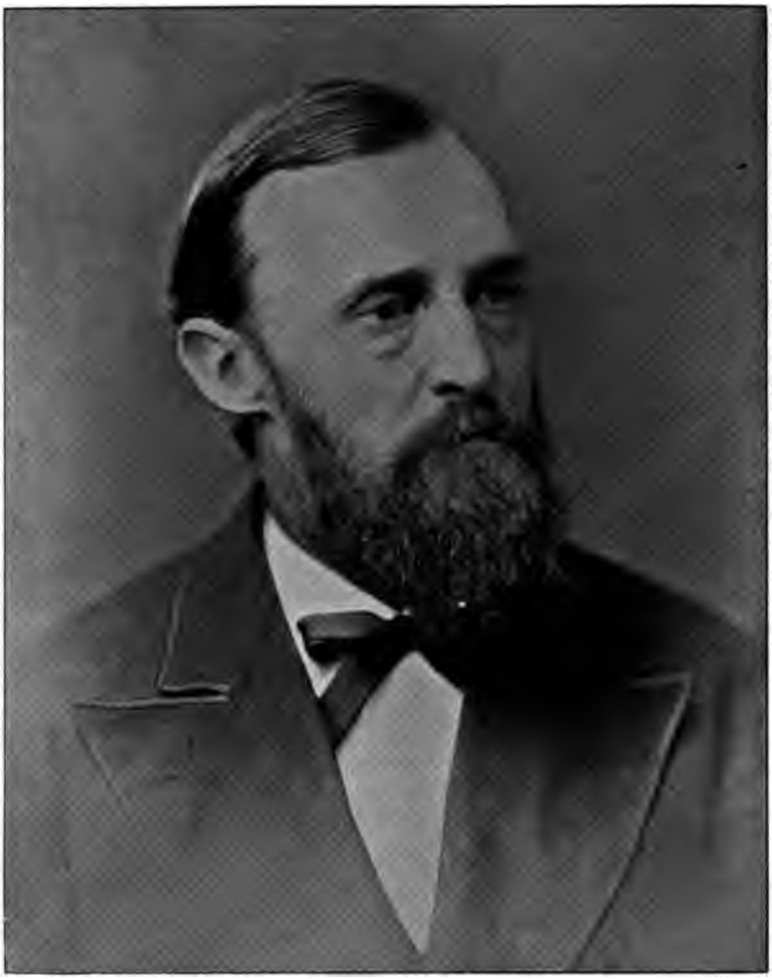
THE SECRETARY OF THE AMERICAN COMMITTEE of the International Congress of Geologists issued a call for a meeting of the committee at New Haven, Conn., Dec. 29th, for the purpose of receiving the reports of the various sub-committees, preparatory to their submission at the London Congress next summer.

THE "SWINDLING GEOLOGIST." We hear again of the scientific swindler who has imposed upon the credulity of so many geologists and others in Minnesota, Iowa, Illinois, Ohio and other states. His personal appearance and methods were fairly described in *Science* this year in the numbers for Jan. 14 and June 17 and 24. But for all this, he appears to have been operating very successfully among the colleges of New York

and New England. He stole from one professor two bound volumes of Chenu's *Conchyliologie;* two unbound numbers of the colored edition of Tryon's *Manual of Ccnchology;* a $20 microscopic objective (Geo. Wales' No. 50) and some fossils. From another college he stole lately a $150 Hartnack microscope. He is said to be well informed and ready. He has been passing lately under the name of L. P. Gratacap, of the "Amer. Mus. of Nat. Hist;" also, in different places as "Ellison" and "Vasile" and "Vasilieff." He pretends sometimes to be a Russian savant, and at other times assumes the rôle of a deaf mute. American geologists will be secure against such impositions if they adopt the old and good English rule of requiring credentials as a basis of confidence and trust.

PROF. G. FREDERICK WRIGHT delivered a course of eight lectures in December before the Lowell Institute at Boston, on "The ice-age in North America." They were presented with plentiful stereopticon illustrations and a large map of North America. Prof. Wright is not satisfied with the evidence that has been adduced to prove that there have been two glacial epochs, and is inclined to believe that man existed in America before the close of the ice-age, which he thinks may be as recent as ten thousand years ago.

AT THE CONCLUSION of the report of Mr. J. M. Hodge, assistant on the geological survey of Kentucky, on the coal fields of the upper Kentucky river, is the following description of a "pounding mill," now in use on Lick branch, Red river, Clay county, Kentucky. "This grist mill is probably the last of its kind in the state, the hand mills, and home-made four-bladed turbines cut from solid wooden blocks, and now in common use, having generally superseded them. The mill consists essentially of a mortar and a pestle; the mortar a short section of a tree in one end of which a hole is scooped out for the reception of the grain; the pestle a straight stick about four feet long, attached to one end of a lever supported in the middle. A weight is hung with the pestle in order to balance the opposite end of the lever, which end has cut in it a hollow place with a capacity of about half a barrel. Water is lead to this trough from the rapidly falling stream by a conduit some 100 feet long, made of the bark of trees, five or six inches in diameter. When the trough is filled with water the added weight causes it to descend, until its inclination is sufficient for most of the water to run out. The greatest weight being then on the other end the pestle falls and lifts the trough into position to be refilled. This see-saw motion continued, it is said, will crush into very nice meal a half bushel of corn left over night in the mortar; and also any stray field mice, or other hungry small animals which may venture into the mortar, left open and unprotected in the forest."



F. V. HAYDEN.

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THE NIOBRARA RIVER, CONSIDERED WITH REFERENCE TO ITS CAPACITY FOR IRRIGATION.

BY DR. L. E. HICKS.

The modern scientist is not a recluse. He has, indeed, his hours of seclusion, his days and weeks of patient labor in laboratory or cabinet, but he does not bury himself there like the alchemist or astrologer of the middle ages. He walks abroad and is conversant with nature and with men, both in the gathering of material for study and in the communication of the results of study. For it is the crowning glory of modern science that its results are not for the private gratification of the investigator, but for the benefit of mankind. Science is a teacher of men but also a servant of men. If, upon the one hand, it furnishes forth for the instruction of mankind crystal truths from deepest mines, eternal laws and principles from starry hights, on the other hand it helps to lift heavy burdens, helps to guide the farmer's plow, the carpenter's plane, the mariner's ship, lends a hand even for the most common drudgeries of life. A principle discovered is soon transmuted into a process for the production of wealth. All industrial progress is due to the application of scientific principles to the problems encountered in each line of effort.

Geology, no less than other sciences, touches at many points the practical life of the millions. The problems of economic geology are numerous, and some of them are so far-reaching that a single one underlies the whole fabric of modern industries. The occurrence of iron ores, for instance, and the production from them of iron and steel, is a problem of economic geology,

and it is so interwoven with all human industries that if the geologist should announce the speedy exhaustion of the supply of iron ore it would produce greater consternation than war or plague. Agriculture, the most ancient and the most important of all industries, is especially benefitted by the labors of the geologist. The very soil which the farmer cultivates depends for its fertility upon the rocks which have produced it by their disintegration. In arid regions the problem of water supply for domestic purposes, for power, and for irrigation, falls to the geologist for investigation.

While The American Geologist will be for the most part devoted to pure science, yet it will not slight or ignore the problems of economic geology. An earnest of the disposition of its editors to do full justice to the claims of applied science may be found in the following discussion of the Niobrara river as an irrigation stream. Many other Nebraska rivers are well adapted for irrigation and I may perhaps report upon them in subsequent papers.

Although such a discussion is primarily of greatest interest to citizens of the localities mentioned, it is not purely local. Irrigation has been practiced from the remotest ages. It is honorable on account of its antiquity, if for no other reason. Incidentally the geology of western Nebraska will be involved in the discussion; also the topography, the scenery, the general physical features and conditions of that region. These topics, it is hoped, will interest all readers however indifferent they may be to the practicability of irrigation.

The early French *voyageurs* in North America had a quick eye for topographical features and striking natural phenomena of any kind. The names they conferred upon natural objects are often as significant as they are beautiful and appropriate. "*La Belle riviere*," the beautiful river, as they called the Ohio, is an example of their good taste and felicity of diction. So they called the Niobrara river "*L'eau qui court*," or Rapid river, from the swiftness of its current. It does indeed glide down its narrow bed with arrowy speed, stretching a silvery thread along the bottom of its valley as it descends from the high plateau of Wyoming, 5,000 feet above the level of the sea. Its mouth is about 1300 feet above tide, so that in the course of

300 miles it falls 3,700 feet, or 12⅓ feet to the mile. This is the average slope, but in some places it descends much more rapidly.

The upper portion of its valley is excavated in the loose friable strata of the newer Tertiary. It is accordingly a broad shallow trough with gentle slopes rising to the adjacent table-lands which are some 300 feet above the river. The serpentine course, the grassy slopes, and the clear swift water, all contribute to impart a peculiar charm to this region, in marked contrast to the rugged features of its lower course. In the vicinity of Valentine, in Cherry county, it is still flowing between walls of Tertiary age, but the rock is more compact and stands up in bold cliffs to the hight of 400 or 450 feet. The broad valley is reduced to a gorge or canon which continues to a point somewhat eastward of the 100th meridian, where the softer Cretaceous rocks yield more readily to aqueous and atmospheric erosion. From this point to its confluence with the Missouri river, the valley is of considerable breadth, and is bounded by moderate slopes.

The Niobrara is an interesting stream throughout its whole course. For the first hundred miles from its mouth the geologist finds the peculiar chalky rocks of the Cretaceous period, with their numerous and very interesting fossils. The Tertiary rocks along its middle and upper course contain the relics of a mammalian fauna unsurpassed in richness and variety. General Warren has stated that the Niobrara flows lengthwise upon the back of an anticlinal fold. This statement I have not personally verified, but, whether true or not, certainly enough is true of this river to make its exploration unusually fascinating to the geologist.

The botanist finds in the valley of the Niobrara a flora quite unique for Nebraska. Great pines wave their branches where, according to any published map of the distribution of pines, none of them ought to be found. A remarkable eastward extension of the Rocky mountain pine (*Pinus ponderosa*) clothes the banks of the Niobrara and its tributaries with an evergreen fringe.

The lover of the picturesque is delighted with the wild and varied scenery of the canons along the middle course of the

Niobrara, as well as the broad green meadows above and the pretty islands below. A waterfall just below Fort Niobrara is worth taking a long journey to see.

But the practical value of the Niobrara for irrigation is of greater consequence than its picturesque scenery. In determining this value the first question is whether the volume of water is sufficient to irrigate much land. On the 4th day of September, 1887, I measured it in the southern part of Dawes county with the following result: breadth, 21 ft., depth, 2 ft., velocity per second, 2⅓ ft. The Niobrara at this point was therefore discharging 98 cubic feet of water in each second of time. This measurement was taken on its upper course and in one of the driest months of a dry year. Lower down, after it has received its large tributaries, the volume of water is far greater, but its use for irrigation is impracticable by reason of the high and steep banks. Just in proportion as the scenery becomes more picturesque, the utility of the stream becomes less. But in the counties Sioux, Box Butte, Dawes, Sheridan, and the western part of Cherry county, the valley is from one to five miles broad, and within it there is an abundance of good irrigable land. The rapid descent of this stream makes it possible to raise its waters to a considerable hight (relatively to its bed) by means of a ditch of no great length. Counting two feet per mile for the slope of the ditch, which is rather more than experience has shown to be necessary, we gain 10⅓ feet per mile. Most of those beautiful stretches of land which the geologist calls terraces, while the farmer calls them second bottoms, and which offer the greatest facilities for irrigation, lie from fifteen to twenty-five feet above the stream. Along the Niobrara these could be watered from a ditch no more than two miles long on the average, since that would give an elevation of 20⅔ feet.

How much land can be irrigated from a stream of the size of the upper Niobrara? If we knew just how many acres can be watered by a flow of one foot per second the answer would be easy. But different soils, different sub-soils, and different crops make such vast differences in the conditions of the problem that its solution is by no means easy. Even when we take into consideration the differences of soils and crops we are hardly pre-

pared for the enormous differences in the practice of irrigators in different parts of the same country. In England one cubic foot of water per second is sometimes applied to a single acre, and in other places that amount is made to serve ninety acres. The usual "water-right" in Colorado is one and a half cubic feet for eighty acres, or 53⅓ acres to the cubic foot per second.

"In California a cubic foot of water is said to be capable of irrigating more than 100 acres, in India 200, and in Spain and Italy a much larger area."[1] "A continuous flow of one cubic foot of water per second will, in most of the lands of Utah, serve about 100 acres for the general average of crops cultivated in that country."[2]

In the absence of direct experiments in the valley of the Niobrara, I shall assume that 100 acres may be irrigated by one unit of water. This will give 9,800 acres for the total amount of land which may be irrigated from the upper course of the Niobrara, if the measurement given above is a fair index of the capacity of that stream. But cannot its waters be used over and over, thus multiplying by a score or more this 9,800 acres? This is a question of great practical interest and importance. Suppose the irrigable land lying in a section of this valley ten miles long amounts to 9,800 acres, and will absorb all the water, will not this water return to the bed of the stream and be ready to irrigate the next section of ten miles? Probably 175 or 200 miles of the Niobrara valley in Nebraska is available for irrigation, and if the river can be used every ten miles then it can be used, say nineteen times, and made to supply 186,200 acres.

But in this computation we are reckoning without our host. A very small portion of the water used in irrigation ever returns to the bed of the stream from which it was taken. It disappears by evaporation, by percolation, and by absorption in the tissues of plants. Evaporation occurs all along the ditches and trenches, all over the surface of the fields, and from the leaves and stems of the growing plants. Vegetation is so largely composed of water taken from the soil (no less than 75 per cent. of ordinary terrestrial plants is water, according to Prof C. E. Bessey) that the vapor of water is constantly escaping from

[1] J. W. Powell, Lands of the Arid Region, p. 143.
[2] Ibid., p. 84.

them, and their stems and leaves expose surfaces which, in the aggregate, are so enormous that the loss of water by this channel probably exceeds all other losses. It has been found indeed, that a plant loses water one-third as fast as a body of water whose exposed surface is equal to that of the plant. A field of growing crops presents surfaces in the form of succulent stems and leaves many times as great as its own superficial area, and all these surfaces are exhaling the vapor of water, the loss of which must be supplied from the soil. We may safely assume that these surfaces are at least three times the area of the field, and since evaporation from them is one-third as fast as from water, the loss will therefore be equal to that from a pond of the same size as the field. In a dry climate this would be very great, but supposing it to be barely one foot over the whole surface during the irrigating season, the loss by evaporation from plants alone would be 426,888,000 cubic feet of water on 9,800 acres. To supply this loss would require the whole capacity of the Niobrara river for fifty days.

The water absorbed and remaining in the tissues of plants must also be considered. If meadow land were irrigated and should produce four tons of hay per acre, the grass when cut would weigh nine tons, of which seventy per cent. would be water. For each acre of land 6.3 tons of water would be taken up in vegetable tissues and remain until harvest. On 9,800 acres 61,740 tons would be used up in this way to supply which would require the whole capacity of the Niobrara river for six hours.

It will readily be seen that the demands of vegetation alone will consume the greater part of the water of irrigation. But this precisely is what irrigation is for, namely, to supply the demands of vegetation. If I have spoken of the water so used as *lost*, it is only with reference to its further use upon other sections of the same valley. It is not by any means *wasted*, though it be "lost" in that sense.

Some water is also lost by percolation. I refer not so much to that which enters the earth along the course of the main ditches as to that which has reached the irrigated fields, and never returns to the stream because it penetrates to depths below its level. That which remains in the earth above the level of

the stream is not lost because it fills interstices which must otherwise be supplied by rains, thus raising the water table, and leaving the rain water to flow off and swell the volume of water available for the next section of the valley. Even the water which sinks below the level of the river contributes to the same result of raising the water table and freeing the rains for surface flow. The loss by percolation would therefore be insignificant if the whole valley were irrigated. In fact, however, only a few fields here and there will be watered, and the dry lands adjacent will drink up much water which might otherwise return to the river.

The farmer who irrigates thus benefits his neighbors directly, as well as indirectly by influencing the rainfall. Those enormous loads of moisture which I have shown to be constantly escaping from growing crops must have an appreciable influence upon precipitation. This should be taken into the account in estimating the amount of land which may be irrigated from the Niobrara river. The increased rainfall resulting from irrigation may double or treble the capacity of the river. This has been almost uniformly the experience of irrigators in Utah. "In many places the service of a stream was doubled, and in a few it was increased ten fold, or even fifty fold."[1]

No direct observations have been made, so far as I know, to determine how much of the water of irrigation returns to the stream from which it was drawn. Fair consideration being given to all the sources of loss by percolation, by evaporation, and by absorption in vegetable tissues, we may state as a probable inference that it is not more than one-tenth. Granting this and then recalling our division of the valley into ten-mile sections, we have in the second section water enough for only 980 acres instead of 9,800 acres; in the third section 98 acres only can be watered, and so on in a diminishing series.

But as a matter of fact the water never is, and cannot easily be, completely used up in any section of the valley. Perhaps by drawing out no more than one-third of it in any section of the valley, much more could be made of it along its whole course than if it were completely exhausted at one point.

It is certain that irrigation does use up a river; else the com-

[1] Gilbert— Lands of the Arid Region, p. 57.

plaints of Nebraskans in respect to the use of the South Platte by citizens of Colorado, are groundless. Within our own boundaries at least, the rights of landed proprietors on the lower courses of rivers may be protected by statute, and no time should be lost in doing this.

Several considerable tributaries of the Niobrara enter it within the irrigable portion of its valley. These may be used for irrigation, each in its own valley, or, if not so used, they go to swell the volume of the river and add largely to the aggregate of acres irrigable from it. My measurement was taken in the dry season and should be raised somewhat to obtain the average capacity of the river.

Summing up all these considerations I am of the opinion that 20,000 acres of land in the Niobrara valley may be irrigated now, and that this may be doubled by the increased rainfall which will probably result from irrigation.

THE FLORA OF THE COAST ISLANDS OF CALIFORNIA IN RELATION TO RECENT CHANGES OF PHYSICAL GEOGRAPHY.

BY JOSEPH LE CONTE.

Some of the results reached by Mr. E. L. Greene in his studies of the flora of the islands off the coast of southern California[1] have deeply interested me, because I believe their explanation may be found in geologically recent changes in the physical geography of California.

These remarkable islands, eight or ten in number, are strung along the coast from point Concepcion southward, and separated from the mainland by a sound 20-30 miles wide. They are of considerable size (the largest being about 200 square miles in extent), and vary in hight from 1,000 to 3,000 feet. They have all the characteristics of continental islands, and are undoubtedly outliers of the mainland, at one time connected

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[1] Studies in the Botany of California and parts adjacent, VI. E. L Greene. 1--Notes on the botany of Santa Cruz island. Bull. 7, Cal. Acad. Sci.

with it, but now separated by subsidence of the continental margin. They may be regarded as the highest points of an old coast range outside of the present coast range, the broad valley between the two being now covered with water. Moreover, the date of the separation may be determined with certainty. That they were connected with the mainland during the later Pliocene and early Quaternary is proved by the fact that remains of the mammoth have been found on Santa Rosa, the largest and one of the farthest off of them.[1] *They were, therefore, undoubtedly separated during the Quaternary period.*

The main points in Mr. Greene's paper with which we are here concerned are the following:

1. Out of 296 species of plants collected by him on the island of Santa Cruz, no less than 48 are entirely peculiar to these islands, and 28 peculiar to Santa Cruz itself.

2. Of the remaining 248 species nearly all are *distinctively Californian*—that is, species peculiar to California are very abundant, while common American species, *i. e.*, those common to California and other parts of North America, are very few and rare. The flora as a whole, therefore, may be regarded as distinctively Californian, with the addition of a large number of species wholly peculiar to the islands.

3. A number of rare species found in isolated patches, and, as it were, struggling for existence, in the southern counties—San Diego and San Bernardino—are found in *great abundance and very thriving condition on the islands.*

4. *Lavatera*, a remarkable malvaceous genus of which 18 species are known in the Mediterranean region, and one from Australia, but *not a single species on the American continent, is represented on these islands by four species.* This is certainly a most remarkable and significant fact.

Such are the facts. I account for them as follows:

California, especially the region west of the Sierra Nevada, is geologically very recent. The Sierra region was reclaimed from the sea at the beginning of the Cretaceous, and the coast region as late as the beginning of the Pliocene. When first emerged the coast region was of course colonized from adjacent

[1] Proc. Cal. Acad. of Sci., vol. v., 152.

parts. This colonization was probably mainly from Mexico, either directly or through the Sierra region; for the distinctively Californian plants, though peculiar, are more like those of Mexico than any other. Whencesoever it may have been colonized, however, the environment was sufficiently peculiar, the isolation sufficiently complete, and the time has been sufficiently long to make a very distinct flora. According to Wallace, it is one of the primary divisions of the nearctic region.

During the late Pliocene and early Quaternary, as already seen, the islands were still a part of the mainland, and the whole was occupied by the same flora, viz: the distinctively Californian (with some differences doubtless), now found in both, together with the peculiar island-species.

During the oscillations of the Quaternary the then westernmost coast range was separated by subsidence, and has remained ever since as islands. Simultaneously with, or after, this separation, came the invasion of northern species, driven southward by glacial cold. Then followed the mingling of invaders with the natives, the struggle for mastery, the extermination of many (viz: the peculiar island species), and perhaps the slight modification of all, and the final result is the California flora of to-day. But the island flora was saved from this invasion by isolation, and therefore far less changed than the flora of the mainland, *i. e.*, the invading species are mostly wanting, and many species survived there which were destroyed, or else modified into other species on the mainland, and the remainder probably less modified than on the mainland. The flora of these islands, therefore, represents somewhat nearly the character of the flora of the whole country during the Pliocene times. Some modification they have doubtless suffered, but the time has been too short for any great change in the absence of severe competition.

The question naturally arises, "How is it that with a separation of only 20-30 miles the two floras—insular and mainland—have not become entirely similar by mutual colonization?" The prevailing winds being landward would, I suppose, largely prevent the colonization of common American forms on the islands, although some such colonization has in fact taken place. But with the prevailing winds in this direction, why have not

all the peculiar island species been long ago colonized on the mainland? According to the view above presented the answer is evident. These peculiar species did once inhabit the mainland and have been either destroyed or transformed in the struggle with invaders. They are, therefore, *weaker* species. The same unfitness which made them succumb then, still forbids their successful colonization. This brings me to the next point.

There are quite a number of rare and peculiar forms found struggling for existence in the southern counties which are found very abundant on the islands. This certainly looks like the beginnings of colonization. This is indeed Mr. Greene's view, and is rendered all the more probable by the fact that the ocean currents probably drift in that direction. But there is at least another explanation suggested by the view above presented. These may be, and probably are, *remnants* of Pliocene indigenes still undestroyed, but ready to perish. From this point of view their place far south is just what we might expect, for the main invasion was from the north.

But there is still a last point to be explained. *Lavateras* are unknown in the New World, except on these islands, where there are four species. But they are found in the Old World, in the Mediterranean region and in Australia. Mr. Greene suggests, as a possible explanation, *a former connection of these islands with some other continent.* I think not. The substantial permanence of continental land masses and oceanic basins, with only marginal changes, at least during later geological times—taken together with the comparative recency of the flora of California—renders this explanation extremely improbable. The above presented view suggests another and far more probable explanation.

The existence of *Lavateras* in such widely separated localities as Australia, the Mediterranean region and the coast islands of California, shows unmistakably that existing species are but remnants of an old, once very abundant and widely spread genus, with numerous species. They are now dying out. They have been mostly destroyed and replaced by newer and stronger forms. I conclude, therefore, that in Pliocene times several species of *Lavatera* existed all over the coast region of

California, but probably mostly in the then coast range, viz: the islands; for they love the sea coast. They have all been destroyed by change of environment, physical and organic, except those isolated on the islands and thus saved from the effects of invasion.

Readers of Mr. Wallace's "Island Life" will at once see the analogy between this explanation of the flora of our coast islands and Mr. Wallace's explanation of the mammalian fauna of Madagascar. The mammalian fauna of Africa, south of Sahara, consists of two very distinct groups—the one *indigenous* or descendants of Tertiary indigenes, and *remotely* resembling that of Madagascar, the other evidently *foreign*, and resembling that of *Eurasia in Miocene and Pliocene times.* During Tertiary times Africa was isolated from Eurasia, but united with Madagascar, and the whole inhabited by a peculiar fauna, characterized by lemurs, insectivores, etc., which we have called indigenes. About middle Tertiary times, Madagascar was separated, and immediately divergence between the two faunas commenced. In later Tertiary and early Quaternary, the barrier which separated Africa from Eurasia was removed, and the great Eurasian animals invaded Africa, and immediately became the dominant type. In the struggle which ensued, many species, especially of the weaker indigenes, were destroyed, and all on both sides modified. The result is the African fauna of to-day. Madagascar was saved from this invasion by isolation. The fauna there consists of the greatly modified descendants of the African Tertiary indigenes, but far less modified than their congeners in Africa. In the fauna of Madagascar, therefore, we have the nearest approach to the Tertiary indigenes of both.

The difference between the two cases is this: In the case of Madagascar the separation has been very long. The extreme peculiarity of its fauna is the result partly of progressive *divergence* and partly of *many forms saved by isolation.* In the case of the coast islands of California, the separation is comparatively recent—there has not been time enough for very great divergence by modification. The peculiarity of its flora is due almost wholly to species saved by isolation.

In conclusion I would say, that this short paper is intended

merely as an incentive to future investigation and pointing in the direction which it ought to take. Before the views above presented can be definitely established, there must be further investigations, first, on the relation of the island flora to that of the mainland; second, on the relation of the flora of California to that of adjacent parts from which it may have been originally colonized; third, and especially, must we have fuller knowledge of the indigenous flora of California in Pliocene times. [*Bulletin No. 8, California Academy of Sciences.*]

OBSERVATIONS ON THE VERTICAL RANGE OF CERTAIN SPECIES OF FOSSILS OF THE HAMILTON PERIOD, IN WESTERN ONTARIO.

BY PROFESSOR S. CALVIN.

The region about Widder, Arkona and Bartlett's Mills in Lambton county, Ontario, has long been classic ground to palæontologists. Clay shales of the Hamilton period are found in natural exposures along the bluffs bordering the Aux Sables river and its tributary creeks near Arkona and Bartlett's Mills. A portion of the same shales has been exposed by the railroad cutting, three quarters of a mile east of Widder. The profusion of fossils of the period occurring in these shales is something remarkable; and the perfect state of preservation in which the fossils are found renders them exceedingly attractive to students of palæontology.

The geological section accessible to observation in the region referred to is probably not more than 200 or 250 feet in thickness altogether. Nevertheless the section is naturally divided into three distinct portions, each sharply set off from the others, not by lithological, but by palæontological characteristics. So marked and so distinct are the groups of species characterizing the three separate portions of the section that it is scarcely an exaggeration to say that not a single species is common to any two of them.

No attempt will be made in the present paper to enumerate all the species belonging to the three distinct assemblages of

fossils on which the tri-partite division of the shales is based, nor will any particular zoölogical order be followed. All that can be done will be to refer to the more obvious and more characteristic forms of each separate group.

We find the lower division of one section exposed, just above the level of the water in the river, below Bartlett's Mills. It may be traced down the river for a number of miles. Near Arkona a little stream flowing toward the Aux Sables has cut a gorge in the shales, known as Rock Glen; and a short distance above the mouth of the stream the lower division is again finely exposed.

One of the most characteristic forms of the lower division is the long-winged variety of *Spirifera mucronata* Conrad.[1] It is true that *Spirifera mucronata* is the most abundant and most characteristic species of the third or upper division, but the varieties from the two horizons show much greater differences than are often observed between two well-established species. This long-winged variety—the variety *d.* of Nicholson, (Pal. of Ontario, 1874,)—has the hinge line greatly extended so that the width is not unfrequently five or even six times the length; the valves are flat, giving the shell a compressed appearance; the plications on each side of the mesial fold and sinus are small and numerous; the mesial fold is divided by a groove and the sinus by a median angular ridge.

Along with the characteristic long-winged Spirifer are asso-

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[1] The name, *Spirifera mucronata*, is here used with full knowledge of the fact that there is a name twenty-one years older than it, applied to this same species. In 1878 S. A. Miller (Proc. Dav. Acad. Nat. Sci., vol. ii, p. 220,) called attention to a neglected article by Mr. Caleb Atwater, in Am. Journal of Science for 1820 (vol. ii, p. 244). In that article Mr. Atwater describes and figures a fossil species under the name of *Terebratula pennata;* and, as Mr. Miller says, a reference to the description and figures leaves no doubt that the author had before him the species that Conrad, twenty-one years later, named *Delthyris mucronata.* The species, therefore, in strict justice should be *Spirifera pennata,* Atwater, but I find it difficult to overcome a natural aversion to disturbing a name as well established in usage and literature as that of Conrad.

The revival of Atwater's name for the species, so long associated with the name of Conrad, would compel a change in the *Spirifera pennata* of Owen, and for this latter species Miller proposes the name *Spirifera atwaterana.*

ciated *Chonetes lineata* Hall, *Tentaculites attenuatus* Hall, a small, very pretty spine-bearing *Platyceras* referred, with some doubt, by Nicholson (Pal. Ontario, 1874,) to *P. dumosum* Conrad, the interesting crinoid with movable spines—*Hystricrinus carpenteri* Hinde (Ann. and Mag. of Nat. History, March, 1885), and *Phacops rana* Green.

It is possible that Phacops is an exception to the rule I have stated regarding the limitation of species, and that it ranges through all three of the divisions into which the Hamilton section is palæontologically divided. Some of the specimens found associated with the species named above may have come from overlying beds of the second division. Nicholson reports it from near Widder where the exposure is wholly confined to the upper division, though my own observations are negative as to its occurence at that horizon.

It may be said, by the way, that the generic name *Hystricrinus* was proposed by Hinde (Mag. and date above cited) as a substitute for *Anthroacantha* of Williams (Proc. Am. Phil. Soc. April, 1883), on account of the fact that Williams' name was practically preoccupied, the name *Arthracanthus* having been employed by Schmarda for a genus of Rotatoria in 1854. (See papers cited and also the paper of Hinde in Ann. and Mag. of Nat. Hist. for March, 1886). Furthermore Wachsmuth and Springer (Revision of the Palæocrinoidea, Pt. III, p. 117), are inclined to regard *Hystricrinus carpenteri* Hinde as probably identical with *Arthroacantha punctobrachiata* Williams.

The small Platyceras referred to is probably a new species, or at least an unnamed variety.

The middle division of the Hamilton section along the Aux Sables is characterized by the great abundance of corals. None of the species already named, excepting *Phacops rana*, pass up into it. The list of species would be a very long one, but we may take *Heliophyllum halli* Ed. and H. as the typical form. With *H. halli* we find associated *Cystiphyllum americanum* Ed. and H., and *Heliophyllum juvene* Rominger. *Diphyphyllum archiaci* Billings is a rare species found in the same association. The favositoid corals are represented by *Favosites billingsi* Rom., *Favosites placenta* Rom., *Favosites arbuscula* Hall, *Alveolites goldfussi* Billings *Alveolites frondosa* Nicholson, to-

gether with a number of other species. One of the most interesting corals is the very pretty, but unfortunately rare, *Microcyclus discus* Meek and Worthen. Of this species the writer obtained quite a number of specimens and is able to confirm Nicholson's determination of the identity of this form with that described by Meek and Worthen in the Geology of Illinois, vol. iii.

There is practically nothing else but corals in the coral zone. Polyzoa of various genera and species are, however, not uncommon. Dwarfed forms of *Spirifera fimbriata* Conrad, are found occasionally. About two miles southeast from Widder there is an outcrop of the coral zone in which *Nucleocrinus* sp., and *Pentremites lycorias* Hall, were found, but these species must be very rare. That most ubiquitous and usually most abundant of all the Hamilton species, *Atrypa reticularis* Lin. is represented in my collections from Ontario by only two or three specimens, and these were found loose near the base of the coral-bearing beds.

The coral bearing stratum is well developed above the beds containing the long-winged Spirifer at Bartlett's Mill; and along the river below the mills it may be seen at intervals for a number of miles. At Rock Glen, near Arkona, it extends from the bottom of the gorge up almost to the summit. Near the summit, however, the corals stop abruptly. The bluffs are crowned by beds of the third division, and into these beds not a single one of the prominent corals of the middle division, so far as we can see, was able to pass.

The third or upper division is the one exposed in the railway cut near Widder. As we have said it occurs at the summit of the bluffs at Rock Glen. It may be seen occupying the same relation to the beds already described at a number of points between Rock Glen and Bartlett's Mills.

In the third division we have an entirely new fauna, so far at least as the prominent forms are concerned. Most abundant of all the species is *Spirifera mucronata* Conrad, but so different from the variety of the lower beds that, were it not for intermediate forms found elsewhere, we should be compelled to regard the varieties of the two zones as very distinct species.

The *S. mucronata* of the upper beds is a thick shell with few

and coarse plications on each side of the mesial fold and sinus; the hinge line is relatively short, in some rare instances it is not greater than the length, though on the average it varies from two to three times the length; the mesial fold and sinus are not divided, and the imbricating concentric striæ are much more pronounced. Altogether the expression and characteristics of the shell are as different from those of the variety occurring in the lower beds as could well be imagined.

With the short-winged spirifers are associated *Cyrtia hamiltonensis* Hall, a small form of *Athyris spiriferoides* Eaton, *Leiorhynchus laura* Billings or *L. multicostus* Hall, *Chonetes scitula* Hall, *Strophodonta nacrea* Hall, and *Callopora incrassata* Nicholson. These are all more or less abundant and conspicuous, though it must be admitted that in numbers and consequent prominence, *S. mucronata* overshadows all the rest.

The only crinoid found in the upper division was a *Taxocrinus*, probably *T.* (*Forbesiocrinus*) *lobatus* Hall. Two entire specimens of *Dalmanites boothii* Green, were found in the cut near Widder, and three other specimens were collected at the corresponding horizon a mile or so below Bartlett's Mills. Pygidia of Dalmanites are more or less common, and seem to have been the only parts of this trilobite seen at these localities, by Dr. Nicholson.

Here then we have three distinct faunas, or at least, if we may not use the term fauna in such restricted sense, we have three distinct assemblages of species in a section of about 250 feet. There is nothing to indicate any break in the continuous and orderly process of sedimentation from the beginning to the end of the time represented by all three of the divisions. Neither do the sediments, so far as lithological characters are concerned, change materially so as to indicate any change in the direction of the currents that carried the material to the place it now occupies. Bluish argillaceous shales, with here and there thin layers more or less calcareous, characterize all three of the divisions. It is true that the upper part of the third division is yellowish, and contains more than the usual proportion of calcareous matter, but the change indicated seems not to have affected the fauna, since the species of the latest beds range down into beds that are lithologically identical with beds of the

middle and lower palæontological divisions. One of two conclusions seems inevitable. Either sediments do not always record changes in physical conditions, or a whole fauna may be blotted out and be succeeded by a totally different fauna without any change in the physical environment. One great factor in the extinction of species, as all biologists admit, is competition with other species. It may be, therefore, that the long-winged spirifers, through some defect in organization and under the conditions existing in that particular locality, were unable to hold their own against an invasion of their territory by corals. While, however, the corals of the middle division of our section were flourishing in undisputed possession of the region, the descendants of the long-winged spirifers that had been forced to migrate and establish themselves elsewhere, were undergoing modifications which fitted them better for the "irrepressible conflict;" and so, when the time is ripe, a hardier and more prolific variety, with shorter hinge and more robust form, descends upon the same region and occupies it, to the complete exclusion of the enemies of their long-winged ancestors. All this at least is conceivable; and notwithstanding the absence of any record to that effect, it is also conceivable that the organic changes so plainly recorded in the Hamilton section of Ontario, may have been aided by mutations in the physical environment.

A SHORT HISTORY OF THE ORIGIN AND ACTS OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS, AND OF THE AMERICAN COMMITTEE DELEGATES TO IT.

BY PERSIFOR FRAZER.

(Continued from the January number.)

The report of the proceedings of the first Congress was published by the Imprimerié Nationale in 1880 under the direction of M. Thirion, secretary of the Central Committee. It forms a volume of 313 pages and is illustrated by seven cuts in all. It probably can be obtained still through any large firm of book sellers but will doubtless be soon out of print.

THE SECOND SESSION, OR THE BOLOGNA CONGRESS.

The committee to prepare for the second session of the Congress in Bologna having received the promise of active aid from that city, and a grant from king Humbert of six thousand francs in addition to his acceptance of the title of "High Protector" of its work, organized a competition for the best solution of the problem of unification of systems of coloration, and other conventional symbols in geological maps, and opened it to all the geologists of the world. It was thought that the propositions of private persons which this competition would provoke added to the labors of the national sub-committees and of the international committee on the same subject would greatly facilitate the ends which the Paris Congress declared were to be attained by the deliberations of the Congress of Bologna; *i. e.* 1, unification of cartographic representation, and 2, unification of nomenclature.

The regulations of the competition were as follows:

1. The prize is for the best proposition for an international color scale and conventional symbols.

2. The color scale should be applicable at least to general maps on a small scale, and must be accompanied by an explanatory essay and by a sufficient number of specimens of maps and sections of regions of different geological characters. The French language is recommended for the essays.

3. The name of the competitor shall be enclosed in an envelope on which a motto or word shall be written which shall be repeated on the manuscript.

4. The essays shall reach Prof. Capellini before May, 1881.

5. The decision shall be made by a committee of five members chosen from among the presidents of the international subcommittees.

6. 5,000 francs shall be paid to the author of a proposition which shall be deemed practicable.

In case none of the propositions be deemed to fulfill the conditions necessary for the award of the first prize, a prize of 1,000 francs shall be given to the most meritorious, together with a gold medal.

Medals of silver and of bronze respectively will be awarded to the essays of the second and third order of merit.

7. The sealed envelopes containing the names of the authors of the best treatises shall be opened during a general session of the Congress, and the names proclaimed.

8. A diploma of honor will be given by the Committee of O ganization to each of the authors of the *three* best treatises.

There were six essays received in time prescribed; four in French, one in German and French, and one in English.

The committee of five to examine these essays was composed of MM. A. Selwyn, A. Ramsay, F. Giordano, V. de Moeller, E. B. de Chancourtois, E. de Mojsisovics, and E. Renevier. Selwyn and Ramsay, however, did not attend, so that the jury consisted of five members only as had been intended. De Chancourtois was elected President.

None of the essays were adjudged to have fulfilled the conditions required of presenting a practicable plan. The three best works were found to have been presented by (1) M. A. Heim, of Zurich; (2) M. A. Karpinsky, of St. Petersburg; (3) M. Maillard, of Lausanne.

These essays are printed in the volume of the proceedings of the Bologna session.

These awards were made public at the opening session of the Congress, September 26th, 1881, and together with the formal speeches constituted all the business which was transacted.

On September 27th various reports of committees, etc., (including one by major Powell from the U. S. Geol. Surv. on nomenclature and cartographic representation,) were handed in. The word "series" was adopted as a term of division intermediate between system and étage by a vote of 52 to 35.

De Chancourtois presented a memoir accompanied by a table on lithologic classification; de Cortazar on geological nomenclature; Mr. Gruner on the geological signification of the word "assise."

September 28th, 1881. The report of the international committee on nomenclature was read and discussed. September 29th. Vilanova's dictionary of geological synonyms was recommended to the attention of the Congress by M. Fischer on behalf of a committee appointed to consider this question. M. Renevier presented the report of the international committee on geological representation in maps. Berlin was decided upon

as the seat of the next Congress. M. Daubrée gave the resolutions of the committee on the geological maps of Europe, adopting the scale at 1—1,500,000 and determining upon the places of meeting of this committee for the two succeeding years. The details of the report of this committee were thoroughly discussed. An able paper by de Chancourtois on the unification of coloration was read, introducing the scale of the spectrum, etc. M. Uzielli added a note on the nature of the colors to be employed for coloring maps.

September 30th was devoted still farther to the discussion of the colors to be employed in geological map making.

October 1st, 1881. The question of the rules to be observed in naming species was brought up. M. Fischer gave an historical sketch of the steps taken in this direction. Hébert, Fontannes, Gillieron, Van den Broeck, Meneghini, Zittel, Dewalque, Emery, Renevier, Blanford, and de Moeller, took part.

Finally the following motion was unanimously adopted. "The nomenclature adopted is that in which every being is designated by a generic and a specific name." This clause was added to paragraph No. 2 of Douvillé which was thereupon adopted. The following important resolution was also unanimously adopted. "In future for specific names the right of priority shall not be irrevocably acquired until the species shall have been not only described but figured."

October 2d, 1881. The Bologna session of the Congress was closed. The next session was fixed for Berlin in 1884; Prof. Beyrich was made President of the Committee of Organization, and Prof. Hughes offered the hospitality of England for the next following session.

In summing up what this session of the Congress had accomplished, president Capellini says: Two laborious sessions have been devoted to the discussion of plans for the unification of nomenclature; two other sessions have been accorded to the question of symbols. There seemed to be great difficulties in our way; nevertheless we have voted several important resolutions and decided upon the execution of a map of Europe. Our last session has been taken up with the consideration of the rules to be adopted in the nomenclature of species, and we are justified in hoping that what we have begun here for palæ-

ontology will be continued usefully with the aid of the zoölogists and botanists. * * *

The council proposed the following resolution which was accepted without dissent. "The Congress decides that an appeal shall be made to the zoölogical and botanical societies, and especially to the former, asking them to unite in the formation of a committee, or of an international congress, which shall have for its object the determination of the laws of biologic nomenclature and the establishment of similar rules in botany and zoölogy, comprising in these palæontology.

Categorically stated the results reached by vote were as follows:

I. *Nomenclature.* (*a*) *Rock-masses.*

1. Group (Secondary, etc.) 2. Systems (Jurassic, etc.) 3. Series, (or section, or Abtheilung—Lower Oolitic, etc.) 4. Etages (piano, piso, stage, Stufe—Bajocian, etc.) 5. Assise (the equivalents in other languages than French not being stated.—Assise A. Humphresianus, etc.) Couche can be employed in French for assise. 7. A certain number of assises constitute a sub-étage. The first element of stratified masses is the couche, Schicht, stratum, strato, Retek (Hungarian).

(*b*) *Chronologic divisions.*

9. Era, applies to the time of groups. 10. Period, to that of systems. 11. Epoch, to that of series. 12. Age, to that of étage.

II. *Colors and symbols.*

1. Crystalline schists, rose-carmine (preferably); deep rose for the rocks of undoubted pre-cambrian age, and pale rose for those of undetermined age. 2. Primary group; decision left to the committee on the map of Europe. 3. Secondary group (Mesozoic); Triassic, violet; Jurassic, blue; Lias, deep blue; Cretaceous, green. 4. Tertiary group (Cenozoic) yellow; light in proportion to the recent age of the rocks. 5. Quaternary deposits; decision left to the European map committee. 6. Resolution of details relating to shades, hachures, and letter notations.

III. *Rules for establishing a nomenclature of species.*

1. The nomenclature adopted is that in which every being is designated by a generic and a specific name.

2. Each name is composed of a single Latin or latinized word, written according to the rules of Latin orthography.

3. Species may present a certain number of modifications related to each other in time or in space, and designated respectively under the name of "mutations" or "varieties;" the modifications of which the original is doubtful are simply called "forms."

The modifications shall be indicated, when there is occasion, by a third term, preceded (according to the case) by the words variety, mutation, or form, or by the corresponding abbreviations.

4. The specific name should always be accompanied by the indication of the name of the author who has established it; that of the author placed in parentheses when the primitive generic name is not preserved, and in this case it is useful to add the name of the author who has attributed it to a new genus. This same disposition is applicable to varieties erected into species.

5. The name attributed to each genus or to each species is that under which they have been longest designated, provided that the characters of the genus and of the species have been published and clearly defined. Precedence shall not go back further than the 12th edition of Linnæus, 1766.

6. In future, for specific names, priority shall not be irrevocably acquired until the species shall have been not only described but figured.

Following the account of the proceedings of the second Congress is a description of the collections and models offered to the inspection of its members, and the lectures and communications presented during the Bologna meeting.

There are "Macrographic classification of the trachytes of Hungary," by Szabò; "Classification of the old stratified formations of the island of Sardinia," by J. S. Bornemann; with two plates and three figures. "On the Cretaceous terrane of the great dunes of sand of northern Sahara," by M. J. Rolland; "The geology of New South Wales," by G. S. Wilkinson;

"Descriptions of excursions to Florence, to Pisa, to Carrara, Ravin de la Morra, Gabbro, and Orciano Pisano. Next follows the essay on a project of unification of graphic methods in geological maps, by Albert Heim, professor of geology at Zurich.

This essay occupies 57 pages, is illustrated by four colored plates, and won the first prize.

Following this is the essay which won the second prize, by A. Karpinsky, professor at the School of Mines in St. Petersburg. It fills nineteen pages and has six colored plates. The essay of M. Maillard which received the third prize occupies 53 pages and is illustrated by two colored plates.

A catalogue of the various works offered to the Congress completes the third part of this volume.

The fourth part contains the report of the national committees forwarded to the international committees. These came from Austria, Belgium, Spain and Portugal, France, Great Britain and Ireland, Hungary, Italy, Russia, and Switzerland.

Following these are reports presented by their secretaries from the three international committees, to wit: by Dewalque on geological nomenclature, etc.; by Renevier on graphic methods of geologic representation; and by Douvillé on the rules for establishing a nomenclature of species. The reports from individuals are added; "On nomenclature and coloring," by Selwyn; "On coloring and notation of geological maps," by de Cortazar; letter of Mr. Hilgard; "Modifications proposed in geological nomenclature," by W. J. McGee; "Unification of nomenclature," by R. Owen; "General nomenclature and conventional symbols," by J. W. Powell; "Résumé of a communication on geological nomenclature and a stratigraphic scale," by N. H. Winchell; "Résumé of the Cambrian rocks of New Brunswick," by Matthew and Bailey; "On coloration and the use of conventional signs," by de Hantken; "On the coloration of geological maps," by Medlicott; and "A system of coloration of geological maps," by Avanzi.

The volume of the Bologna session contains 661 pages and might well serve as a model of the most perfect typographical art which our age can produce. The color printing, from the seal of the Congress on the first page to the color plate facing

page 526, is simply unsurpassable at the present time, and speaks volumes for the vigor, liberality and alertness of Italian science.

THE THIRD SESSION, OR BERLIN CONGRESS.

The subsequent history of the Congress down to the end of the Berlin meeting has been given to the public both through the pamphlet of the writer on "The work of the International Congress of Geologists and its committees," published by the American committee, and in numerous communications to the scientific press.

A brief résumé of these will here be given for the better enlightenment of those who have formed their opinions of the Congress from vice president Gilbert's address before Section E at the last meeting of the A. A. A. S. in New York.

M. Renevier on behalf of the international committee on the geological map of Europe, reported that it had assembled in 1882 at Foix, and in 1883 at Zurich. He announced the arrangements made with the firm of D. Reimer and Co., of Berlin, for the publication of the map, and that Prof. Kiepert would provide a base which should include all new data both published and unpublished.

Each of the great European States (viz: France, Spain, Italy, Austro-Hungary, Russia, Scandinavia, Germany, and Great Britain,) had agreed to take 100 copies of the map, when completed, at a cost of 100 francs each.[1]

[1] The secretary of the American committee was authorized to state to the international committee on the map that the United States would take 100 copies under the same conditions as the above named countries.

Inasmuch as the United States government cannot be counted upon to subscribe by an appropration of money, he was orderd to send out circulars and to procure subscriptions of institutions and individuals. This he has done, no less than three circulars having been addressed by him during the last two years to the persons mentioned in the catalogue of the members of Section E, A. A. A. S., in his own and the scientific exchange list of the United States geological survey., and to the individuals and institutions mentioned in Cassino's *Scientist's Directory*. Besides this, every institution of learning recorded in the report of the "Educational Bureau" was addressed. Yet notwithstanding these expensive and laborious efforts to reach all classes of the American public likely to be interested in either the best map of Europe, or the science of geology but 75 copies of the 100 have been subscribed for. It is true that all the

The international committee adopted the suggestions of the Bologna Congress as to the colors to be employed, and decided in the cases left to its judgment, (*a*) to represent the Carbonic system (or Permo-Carboniferous) by a gray color in three distinct shades; (*b*) to assign to the Devonic system shades of brown; (*c*) to assign greenish gray to the Siluric; (*d*) to represent the eruptive rocks by seven tints of red. Subsequently to the Berlin session this committee decided, as recommended at Bologna, to employ lower case Roman letters to distinguish the terrancs of sedimentary, and small Greek letters those of eruptive origin. The lesser divisions were to be made by small figures used as indices, thus: a^1, a^2, a^3, were lower, middle, and upper Archean, m_1, m_2, m_3, m_4, for the Tertiary, etc.

In the Greek letters ν stands for lavas of modern volcanoes, and ν' for tufas and out-throws from said volcanoes, etc.

The international committee on the unification of nomenclature made a careful report based upon the sentiments expressed at the Congress of Bologna, and proposing solutions for many of the difficult problems of the subject. It added to its report in the same spirit the scheme of Prof. Lossen for the classification of the eruptive rocks.

This scheme, as well as the final arrangement of the Cambrian, the division of the Archean, the decision as to the place of the Permian, etc., were simply offered in order that some project might be formulated and the way prepared for intelligent discussion.

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great universities and many of the libraries of the United States and the government institutions are already on the list, but the complete number should have been disposed of long ago. When it is considered that this map consists of 49 sheets, seven in breadth and seven in length, which when put together will cover an area of 12 x 11 feet more or less; that it will be a far more accurate topographical and geographical map than exists at present; and that the newest determinations of the government geological surveys of Europe will be placed upon it, its cost ($26.00 to individuals and $21.00 to public institutions, everything paid) seems trifling. Will not the readers of this forward to Dr. Persifor Frazer, 201 South Fifth street, Philadelphia, the names of enough subscribers to take up the remaining 25 copies, and thus relieve the committee from the necessity of withdrawing the name of the United States from the list of "great states" subscribers? P. F.

The charge which has been occasionally made by those who do not sympathize with the aims of the Congress, that the latter or its committees forced decisions upon these points upon the general body of geologists, is distinctly without foundation in fact. This will become evident when it is considered that the only votes taken at Berlin were:

1st. That the map committee should select for experiment on the map of Europe, gray tint for the Carbonic and Permian.

2d. That this committee "*Might adopt provisionally according to its choice a scheme of colors for its convenience, and that this choice should not decide the scientific questions concerned therewith at all.*"

3d. For the map experiment the eruptive rocks should be represented by seven tints of red.

4th. The solution of other questions which might arise in the construction of the map were left to the decision of the committee.

5th. The word "group" was decided upon for the most comprehensive division.

6th. "Archean" was decided upon for the name of the lowest division.

7th. "Protogine" was abandoned as a division.

8th. The divisions in the Archean group were left to each geologist without assigning to such divisions any chronological value.

9th. The upper limit of the Devonic system is to be placed at the base of the Carbonic limestone, that is to say, the system comprises the psammites of Condroz and the upper Old Red.

Many of the most difficult questions were left specifically to the investigation of the international committee and the decision of future Congresses, and all others were so relegated by tacit consent.

It must be conceded, therefore, that the Congress has been very chary of assuming responsibility, and most anxious to leave the settlement of vexed questions to the labors of original investigators.

First meeting of the American committee.

A few months after the adjournment of the Congress and the return of the American delegates to this country, the presi-

dent of the American committee instructed the acting secretary of the committee during the Berlin Congress, Dr. Frazer, to call a meeting of the committee at the Windsor hotel, New York, on Friday, January 8th, 1886.

There were present Hall, Hunt, Newberry, Hitchcock, Stevenson, Cook and Frazer.

Mr. McGee having been sent by major Powell to represent him was by vote of the committee authorized to take part in the proceedings. Dr. Newberry moved that the report of the proceedings of the Congress be prepared by the secretary, Dr. Frazer, from the notes he took at Berlin, and that a translation by him of the reports of the two international committees be added to the report of the proceedings. He was also directed to write an address to American geologists as a preface to the report.

It was decided to secure the coöperation of the scientific societies of the country to secure a meeting of the Congress in the United States, next after its meeting in London.

Second meeting of the American committee.

A second meeting of the American committee was held in the Murray Hill hotel, New York, May 22d, 1886, at which were present Hall, Williams, Cook, Stevenson, Cope, Newberry, and Frazer.

After routine business, the committee of five which had been appointed at the first meeting "to discuss the attitude of American geologists toward the decisions of the next Congress" etc., was enlarged into, practically, a committee of the whole, divided into seven sub-committees, each of which was charged with the duty of formulating American opinion on its own particular subject.

(These sub-committees, as finally arranged, will be given in the proceedings of the next meeting.) Committees were appointed to provide for the distribution of the 100 copies of the European map which the American committee had decided to order in the name of the United States. The secretary was instructed to prepare a report of the work of the committee, for presentation at a general session of the A. A. A. S. A copy of the Procés Verbaux of the three sessions of the committee

on the European map, held in Berlin, were presented to the American committee by Dr. Frazer, secretary.

Prof. Williams was elected treasurer of the American committee.

Third meeting of the American committee.

A third meeting of the American committee was held in Philadelphia at the University Club, December, 28th, 1886. There were present: Hitchcock, Williams, Stevenson, Frazer. Dr. Hunt's resignation as secretary of the American committee was accepted. The following list of sub-committees, with their chairmen, was received from the president and read: *Archean*—Hunt, Hitchcock, Winchell, Pumpelly, Frazer. *Lower Paleozoic*—Hall, Winchell, Lesley. *Upper Paleozoic*—Hall, Lesley, Dawson, Newberry, Stevenson, Williams. *Mesozoic*—Newberry, Cook, Cope, Powell. *Cenozoic* (Marine)—Eugene A. Smith, Newberry. *Cenozoic* (Interior)—Cope. *Quaternary*, Recent, and Archeology.—Powell, Winchell, Cook.

Sir J. W. Dawson's resignation from the American committee was accepted.

Fourth meeting of the American committee.

A fourth meeting of the American committee was held in Albany (State Hall), on April 6th, 1887; present: Hall, Hitchcock, Cope, Stevenson, Williams, Winchell, Cook, and Frazer.

Prof. Winchell moved that the decisions of the International Congress be accepted by this committee, and that their acceptance be recommended to American geologists. This motion, with the modification "that we will be prepared to ask the next Congress for a few changes," was finally adopted.

Preliminary reports on the subjects referred to sub-committees were then read and discussed. Reporters were appointed for the various sub-committees and charged to get ready reports for presentation to the American committee at its next meeting, just before the next meeting of the A. A. A. S. in New York, in August. These reporters were: *Archean*—Frazer; *Lower Paleozoic*—Winchell; *Upper Paleozoic*—Stevenson and Williams; *Mesozoic*—Cook; *Interior Cenozoic*—Cope; *Marine*

Cenozoic—Smith; *Quaternary, Recent, and Archeology*—Powell.

The secretary sent out a circular, which was also printed in "Science" and in the "Am. Jour. of Science," announcing the names of the reporters and asking all geologists to communicate their views. This circular was signed by all the reporters but major Powell, who took no notice of the letter addressed to him.

Fifth meeting of the American committee.

The fifth meeting of the committee was held at Spring Lake, New Jersey; present: Powell, Smith, Cook, Williams, Winchell, Hitchcock, Cope, Frazer.

Reports were read on the Archean, Lower Paleozoic, Upper Paleozoic (Devonic), Upper Paleozoic (Carbonic), Mesozoic, Interior Cenozoic, Marine Cenozoic. All the reporters were present except Prof. Stevenson, but major Powell stated that he had prepared no report, and gave a verbal statement instead on the Quaternary.

Major Powell opposed any vote of acceptance of these reports by the committee, and in deference to his wish no vote was taken. The committee was ordered to report its preliminary recommendations to Section E, on the assembling of the A. A. A. S. the following week.

The week following this meeting of the American committee and during the A. A. A. S. meeting, August 12th was set apart by Section E. for hearing the reports of the American committee which the secretary accordingly read in abstract. Vice president G. K. Gilbert, of the U. S. Geol. Survey, the president of the Section, whose address had been an unfavorable criticism of the Congress, decided at the outset that "no vote in relation to the reports was in order inasmuch as these reports had not been adopted by the committee but were merely the individual opinions of the reporters making them." Nevertheless by unanimous consent, president Gilbert permitted a resolution of approval of the work of the committee (to which major Powell had added an amendment increasing the number of members of the committee to seventy-five), to be brought before the Section, but, there being apparently much opposition to the amendment, declared the Section adjourned to go upon an ex-

cursion. On the reassembling of the Section in the evening major Powell withdrew his amendment and the resolution was unanimously carried.

Sixth meeting of the American committee.

After the adjournment of the Section a sixth meeting of the American committee was held on August 15th, 1887, in Columbia College, at which routine business was transacted.

Before this is put into type a seventh meeting of the American Committee will have been held in New Haven.

The question which most concerns American geologists is, what attitude they propose to assume toward the body of their own creation. A Congress of experts from every country on the globe assembled to clear away the confusion arising from misuse of terms, synonymy, and local prejudices, and thus to facilitate the progress of science, is a distinctively nineteenth century idea. Not that it originated with the gentlemen who called this geological Congress into being; for the experiment had been tried on numerous occasions before; but no science needed such assistance more than geology, which is peculiarly liable to death by drowning at the hands of any one who is provided with a few terms, the physical power to walk over the country in his own neighborhood, and an ambition to be seen in print. Unlike astronomy, and physics, and mechanics and chemistry, which are removed from the touch of the idly profane by the expensive tools required to prosecute them (the first three being also additionally guarded behind the strong wall of mathematics) geology requires a properly trained imagination if its disciple would rise above the level of a mere collector. Instead of this it is but too frequently treated to an imagination without safeguards, a commodity which not only invalidates conclusions made in its name but even vitiates its supposed facts. A single statement distorted, whether accidental through ignorance, or purposed through a desire of notoriety, concerning a phenomenon which cannot be again observed, may act for years as a bar to a consistent theory of a group of facts in which it ought to be one component. How vitally important then that the individual errors of work in such a science, the parallax of national or bureau vanity, the

acidity of personal biliousness, and the depreciation of the competency of workers whose language and customs we do not understand, should be eliminated. No one man or class of men from one or two countries knows enough to propose the best plan for thorough mutual assistance.

If the older sciences had been able to avail themselves of this plan of mutual help, it is not doubtful that they would be far more advanced now than they are. The plain moral is that every true scientific geologist the world over should enter into hearty sympathy with the work of the Congress, knowing that by the coöperation which it secures, the advance of the science must be immeasurably greater than it could be from the divided energies of a handful of leaders, each using the resources of his government to enable him to show that all the rest are hopelessly wrong and himself phenomenally and wholly right.

A CORRELATION OF THE LOWER SILURIAN HORIZONS OF TENNESSEE AND OF THE OHIO AND MISSISSIPPI VALLEYS WITH THOSE OF NEW YORK AND CANADA.

BY E. O. ULRICH.

As expressed in the above title, the chief purpose of this paper is to determine the equivalence of the various beds comprised in the Trenton and Nashville series of Tennessee, those of the Trenton limestones of Kentucky, the Cincinnati and Hudson horizons of Ohio, Indiana, and Kentucky, and all of the beds of Illinois, Iowa, Wisconsin, and Minnesota, included between the St. Peter's sandstone and the Niagara limestones, with the typical rock sections in Canada and New York.

Since 1879 I have been gathering data bearing upon questions involved in this study, yet I cannot say that I am fully prepared to solve any beyond doubt. Whenever possible, I have personally visited the typical localities, to either corroborate or correct the observations of others. These explorations, however, have not been so extensive as was desirable, but when combined with the facts gathered by the geological surveys of

the various states in which the rocks under consideration are exposed, a nearly conclusive correlation seems possible. Being especially interested in palæontological problems, it follows that stratigraphy and the lithological peculiarities of the various beds to be discussed, though not by any means ignored, have, nevertheless, been subordinated to evidence furnished by their fossil contents.

In late years a disposition to undervalue palæontological evidence, as determinative of the position and inter-relation of strata, has been making itself felt. That stratigraphists and lithologists have some excuse for abandoning their confidence in determinations based upon fossil evidence, I am willing to admit. Still, I am confident the fault lies not so much with the fossils as with their identifiers. What possible value can a determination of any of the Lower Silurian divisions have, which, among a total of five or six doubtful species, mentions several of such long-lived forms as *Strophomena alternata*, *Zygospira modesta*, *Orthis lynx*, *O. testudinaria*, *Murchisonia bicincta*, *Pleurotomaria* (*Raphistoma*) *lenticularis*, and *Pleurotomaria subconica?* Besides these we almost invariably find that the lists contain *Monticulipora* or *Chætetes petropolitana*, *lycoperdon* and *fibrosa*, three names that together have been applied to no less than fifty distinct species. I ask again, what value can an identification resting upon such grounds have? Practically none.

The determination of particular stratigraphical horizons by means of their characteristic organic remains is sufficiently difficult even under the most favorable circumstances. Still geologists have little or no excuse for faulty determinations, since, if correctly identified, the fossils furnish very reliable data. In my opinion, at any rate, it is by far the most reliable and ready evidence obtainable. Species known to have great vertical range are of course not available for the identification of the minor geological divisions, except to expert palæontologists. They are of great use to the skilled, because he is capable of noting every change in the development of the species, and I believe I can claim without fear of contradiction, that scarcely a single form passes from one recognizable division of rocks to another without sustaining a more or less marked change. Sometimes

the change is very slight indeed, but in most cases the practiced eye has little difficulty in recognizing it. We have men, naturalists too, who are capable of appreciating very minute distinctions, but when called upon to separate a lot of fossils, they cannot see the differences, and because they cannot see them, they reason that they do not exist. Such reasoning is, however, not good, as their inability to see is simply due to a lack of education and training in this particular department. Many minute and seemingly trivial variations exist, which are ordinarily (especially by the stratigraphist) not at all taken into account. Yet they are of the utmost importance in stratigraphical determinations. Their value as markers of particular horizons must be manifest to all who can see that, if, (all things being equal,) large variations required a long time in their production, smaller deviations needed a correspondingly shorter time; hence, that the equivalences indicated by them are necessarily closer and more trustworthy.

We can not, of course, demand that the geologist who has made lithology and economic geology his principal studies, should also make himself familiar with the minute details of palæontological subjects. No, geology has advanced too far to be mastered in detail by any single mind. We may, however, reasonably expect that he will join forces with special students of palæontology, for thus only are uniformly successful results possible.

The subject of the study here contemplated, embraces three basins or large areas of exposures, besides several small patches along the Mississippi river in Illinois.

In order that the reader may follow the evidence presented and form his own conclusions with the progress of the paper, I shall first consider each of the several series separately and without comment upon their equivalences, reserving the conclusions until after all the facts relating to the questions at issue have been presented.

As the series is more complete and the exposures more extensive in the Ohio valley than in either Tennessee or the northwest, they are taken up first, leaving the consideration of those of central Tennessee, northern Illinois, Iowa, Wisconsin, Minnesota, Canada and New York to follow in the order named.

The lowest rocks of this series are exposed in the gorge of the Kentucky river near Camp Nelson. From this point, which is at the summit of what the Kentucky geologists have called the "Kentucky anticlinal," all the superposed strata dip rapidly to the south-east, and more slowly to the north-west, while in a due northerly direction, a very gentle dip, averaging nearly six feet to the mile, prevails far into south-eastern Ohio.

Fine natural sections of the lower rock are presented in the almost vertical cliffs that border the Kentucky river along its course between Jessamine and Woodford counties on the north, and Mercer, Garrard and Anderson counties on the south. To the north and south of the river the topography of the country gradually rises, bringing to the surface the succeeding layers of the series. On the southern side of the river, the rate at which they are brought up is moderately rapid for the first four miles, along the Cincinnati Southern R. R., slower for the next three miles, and scarcely appreciable during the following six or seven miles. At this point, which is situated a short distance south of Danville, the summit of the Kentucky anticlinal crosses the line of the R. R. in a north-east and south-westerly direction. A fault in this region brings up the sixth member of the series, which had already been passed at a point three and a half miles south of High Bridge. The dip of the rocks beyond the summit of the anticlinal, which in this region has a more easterly and westerly direction than usual, is rapid, causing the rest of the Lower Silurian strata, here about 700 feet in thickness, to pass under the overlying Corniferous limestones and black shales at a point near McKinney's station, twenty-nine miles south of High Bridge. Between Danville and McKinney's station small patches of black shales are frequent, but I have not met with any exposure of Lower Silurian strata south of the last locality named.

To the north from the river the country rises at first more rapidly than on the southern side, but beyond Nicholasville the strata are nearly parallel with the surface as far as Georgetown, thirty-three miles north of the river at High Bridge. From Georgetown to Roger's Gap, slightly higher strata make their appearance in the railroad cuts. At the last locality a large cut exposes the dark drab shales and thin, sandy layers of limestone, which do not again come to the surface until we reach

the Ohio river at Cincinnati. From Roger's Gap to Cincinnati the road bed gradually passes over all the strata exposed in the hills skirting the south bank of the Ohio river, the highest beds exposed in the cuts being equivalent to those met with in the Cincinnati hills at a hight of about 375 feet above low water mark.

As is well known, the lowest beds exposed in Ohio are seen in the bank of the Ohio river near Point Pleasant. These I regard as representing a horizon between forty and fifty feet lower than those seen at low water mark at Cincinnati. From the base of the Point Pleasant beds to the top of the Cincinnati series, there are nearly 800 feet of shales and thin layers of argillaceous to crystalline limestone. To the southeast and northeast of Point Pleasant the beds dip more rapidly than to the westward, so that while the upper layers pass under the river bed about eighty miles west of the Point, they already disappear at about forty-five miles eastward. To the north, northeast and northwest of Cincinnati they pass under the Upper Silurian deposits, at distances varying from twenty-seven to seventy miles.

In a general way the above briefly describes the distribution of the members of the series as they are met with along a north and south line passing nearly through the center of the area of which they form the surface rocks. I now propose to take up successively each division, giving in moderate detail its lithological characters, thickness, localities of outcrop, and other features of interest, and, more particularly, the characteristic fossils. Of the latter the names of only such species as are known to occur in two or more of the four distinct areas will be mentioned. At the close of the paper some remarks relating to the distribution and extent of the fauna will be in order.

To prevent anticipation, I shall designate each bed that shows peculiarities of either a lithological or faunal character with its respective numerals as it occurs in the section from below upward. This plan will be followed with all excepting the New York and Canadian sections.

In the Kentucky section,[1] beds No. I, show a thickness of

[1] The Lower Silurian rocks of central Kentucky have been ably reported upon by the lately deceased Mr. W. M. Linney, assistant on the Kentucky geological survey. I bear willing testimony to his zeal and the unusual accuracy with which he has worked out the various beds.

about 350 feet in the gorge of the Kentucky river near the mouth of Cooper's branch. Following the outcrop in a southeasterly direction up the river, it will be found to dip rapidly, passing out of sight within three and a half miles. Going down the river the dip is much less abrupt, the top being nearly 200 feet above the water at High Bridge, and not reaching the water's level until near Tyrone in Anderson county.

These rocks are usually fine-grained, hard and tough, and generally of a dark drab or dove color. Some are slightly crystallized and grayish, and many have a faintly mottled appearance. Almost throughout they are heavy bedded, some of the layers being twenty feet or more in thickness, but the majority vary between one and two feet. Fossils are few, yet at several horizons there are a few thin layers with shaly partings, that are largely made up of organic remains. Such a horizon was noticed near High Bridge at about 150 feet below the top layer. Here the following species were collected:

Orthis subequata Conrad.	*Dalmanites* sp.
The shell named *Atrypa dubia*, by H.	*Bathyurus* (two species.)
Maclurea magna Hall.	*Leperditia canadensis* Jones.
Raphistoma planistriata, var. *parva* H.	*Leperditia? tumida n. sp.*
Orthoceras explorator Billings.	*Beyrichia? bicurvata n. sp.*
Orthoceras furtivum Billings.	*Beyrichia persculpta n. sp.*
Pterotheca (a small species.)	*Stictopora fenestrata* Hall.
Cypricardites sp.	*Mitoclema cinctosum* Ulrich.
Conchicolites (a very small species.)	Several undet. species of Bryozoa.

Some of the species were abundant, particularly the Ostracoda. Between the top layers and sixty-five feet below there are several intermittent horizons that have furnished a few fossils.

Here *Strophomena incrassata* Hall, *Rhynchonella plena* Hall, *Orthis costalis* Hall, and *Maclurea magna*, are sometimes numerously represented, while an occasional specimen of *Asaphus? marginalis* Hall, may be found.

Beds II. This is a regularly bedded, dolomitic limestone, about ten feet in thickness, of a gray color, with greenish, bluish, or brown blotches. The whole, when weathered, assumes a color approaching buff. These rocks have received the name "Kentucky marble." Being unfossiliferous their principal interest, in this connection, consists in the fact that they are very persistent both in their thickness and lithological characters, having been met with in deep well-borings as far north as Cincinnati.

Beds III. The lower layers of this division, which comprises about 100 feet of mainly gray to light drab limestones, closely resemble the heavy, tough beds of division I. Some are rather brittle and break with a conchoidal fracture. The gray layers are commonly thin-bedded and slightly crystalline. The middle layers are of drab color, variously bedded, very fine grained, rather soft, with frequent crystals of calcite and occasional specks of iron pyrites. Toward the top the beds become shaly, of a light dove color, and highly fossiliferous. The top is marked by a gray crystalline layer two or three feet thick, plated on the upper side with several thin layers of red chert, almost made up of the valves of *Leperditia fabulites.*

In the lower heavy bedded layers, fossils are very few, but near High Bridge several good fragments of undetermined trilobites were found. They belong to four species, one an *Asaphus*, the others apparently referable to *Bathyurus*. One of the latter is identical with a form found 150 feet or more below the top of beds I, while another recurs high up in the present beds. The middle layers are almost destitute of fossils, but the peculiar markings which Hall has described under the name *Phytopsis tubulosum* are abundant. Higher up, *Phytopsis cellulosum* Hall, which is clearly a lax-growing form of *Tetradium*, is met with. The upper twenty feet or shaly portion of the beds, are highly interesting to the palæontologist, as they contain thin plates of limestone literally filled with organic remains. The fossils, too, are in an exceptionally good state of preservation. The following should be mentioned:

Tetradium cellulosum Hall sp.
Ptilodictya ramosa Ulrich.
" *libana* Safford.
Stictopora labyrinthica Hall
" *nicholsoni* Ulrich.
Phyllodictya frondosa Ulrich.
Helopora spiniformis Ulrich.
Phylloporina (a species near or identical with *P. trentonensis*.) Nicholson.
Monticulipora wetherbyi Ulrich.
Homotrypa ramulosa Ulrich.
Orthis subequata Conrad.
" *tricenaria* Conrad.
" *deflecta* "
Streptorhynchus filitextus Hall. (The typical form.)
Streptorhynchus filitextus ? var. *a*. (A thinner form.)
Subulites elongatus Conrad.
Pleurotomaria subconica Hall.
Helicotoma n. sp.
Trochonema umbilicatum Hall
Ormoceras tenuifilum Hall.
Orthoceras multicameratum Hall.
" *amplicameratum* Hall.
" four undet. species, one with strong annulations
Cyrtoceras planodorsatum Whitfield.
" *bondi* Safford.
Endoceras sp.
Conularia quadrata Walcott.
Pterotheca attenuata Hall.
Cypricardites ventricosus Hall.
" *subtruncata* Hall.
" *subcarinatus* Bill.
Leperditia fabulites Conrad.
" ? *tumida n. sp.*
Beyrichia persculpta n. sp.
" ? *bicurvata n. sp.*

The Ostracoda and some of the Bryozoa are exceedingly abundant. Where these beds come to the surface red cedar is the prevailing tree.

Beds IV. Resting upon the rocks just described, I find from twenty to twenty-five feet of decidedly cherty layers, the blocks of hornstone giving them a rugged aspect when worn. The soil formed by them is of a light red color. I have met with these layers only in Mercer county, about two miles south of High Bridge, where they are shown in several small cuts along the Cincinnati Southern R. R. Here they consist of unequal but never thick layers, made more or less irregular by the hornstone, which of itself may form irregular layers. Near the middle of the beds there is a very soft clay layer, about two feet in thickness, nearly white, with often a greenish tinge. Some fragments were seen in which the green color is decided. It has a peculiar unctuous feel, is readily cut with a knife, and when exposed a short time to the atmosphere breaks up into small flakes.

Fossils are moderately abundant in these beds, but, so far as observed, occur only in or on the surface of the blocks of hornstone. All are silicified, and the most of them very difficult to obtain in good condition. A species of *Helicotoma*, which seems identical with *Pleurotomaria numeria* Billings, is very common. The other fossils are:

Helicotoma n. sp. (*a*) (also in division 3.)
Murchisonia tricarinata Hall.
Orthoceras (4 or 5 undet. species.)
Cyrtoceras planodorsatum Whitfield.
Camerella panderi Bill.
Orthis bellarugosa Conrad.
Columnaria halli Nich.
(--*C. alveolata*, American authors. *non* Goldfuss.
Stromatocerium rugosum Hall.
Calathium formosum Bill.

Beds V. Succeeding beds IV we find a series of heavy bedded, coarse, sub-crystalline, gray rocks, about thirty feet thick. They are siliceous and argillaceous, decompose rapidly, are overlaid by heavy beds of dark red clay, containing large numbers of silicified fossils and some nodules of chert. The best section seen of these rocks occurs along the line of the Cincinnati Southern R. R., where they are exposed in a cut nearly three miles south of High Bridge. Just beyond the cut, on the east side of the track, the overlying clay has been scraped away to use in filling. The rugged rocks are here exposed in places

and the rains have served to wash out many interesting fossils from the clay, which still partly covers them. They are rather coarsely silicified, causing all the finer details of structure to be destroyed. Still they are usually in a sufficiently good condition to render their identification comparatively easy. Among others the following should be mentioned:

Receptaculites occidentalis Salter.
Streptelasma corniculum Hall.
" *profundum* Hall.
Columnaria goldfussi ? Bill (*C. carterensis* Safford.
Glyptocrinus priscus Bill.
Blastoidocrinus carcharidens Bill.
Hybocrinus tumidus Bill.
" *conicus* Bill.
Porocrinus conicus Bill.
Carabocrinus radiatus Bill.
Palaeocrinus angulatus Bill.
Dendrocrinus acutidactylus Bill.
" *jewetti* Bill.
Cleiocrinus regius ? Bill.
Amygdalocystites florealis Bill.
" *radiatus* Bill.
Anomalocystites sp.
Pleurocystites (species near *P. squamosus* Bill.
Edrioaster bigsbyi Bill.
Phyllodictya frondosa Ulrich.
Orthis tricenaria Conrad.
" *pectinella* Hall (abundant)
" *deflecta* ? Conrad.
Platystrophia lynx var *a*.
Streptorhynchus filitexus Hall.
Zygospira recurvirostris Hall.
Rhynchonella subtrigonalis Hall.
Bellerophon bilobatus Sowerby.
" (*Cyrtolites*) *macer* Bill.
Bucania punctifrons Emmons.
" *bidorsata* Hall.
" *buelli* Whitfield.
Pleurotomaria progne Bill.
" *hyale* Bill.
Trochonema umbilicatum Hall.
Cyclonema percarinatum Hall.
Murchisonia alexandra Bill.
" *milleri* Hall (typical.)
" *hermione* ? Bill.
Ormoceras tenuifilum Hall.
Orthoceras arcuoliratum Hall.
" *amplicameratum* Hall.
" *planoconvexum* Hall.
" (seven undet. species.)
Endoceras multitubulatum ? Hall.
" sp. undet.
Phragmoceras sp. undet.
Cyrtoceras (five undet. species.)
Colpoceras gracile Wetherby.
Pterotheca sp. undet.
Tellinomya astartiformis Salter.
Cypricardites hayniana ? Saf.

Beds VI. These beds seem to vary somewhat in thickness, but on an average may be said to be about thirty feet thick. At the base there are generally a few light drab layers that are slightly siliceous and charged with a large form of *Orthis testudinaria*. The remainder is made up of hydraulic limestones, which weather to a dark grey or drab color. They form rather even layers of from one to eight inches in thickness, with often shaly partings of like color.

These beds are seen in a cut about three and one-half miles south of High Bridge, again in the bank of a creek a half mile south of Danville, where a fault brings them to the surface, at Frankfort and other localities in central Kentucky.

The fossils in these beds are not evenly distributed, being abundant in some of the layers and rare in others. Near the

middle there is one which holds many specimens of a new species of *Modiolopsis*. It usually occurs in the shape of casts of the interior, but examples retaining the shell are not uncommon. Some feet higher there are several thin layers holding an abundance of a small hemispheric species of *Prasopora*, one inch or less in diameter, while at the top I have met with a layer about one foot in thickness in which the fossils (*Tetradium* and several *Gasteropoda* are silicified. The *Lingulæ* are almost restricted to the shaly layers. Following is a list of the principal species:

Tetradium minus Safford.	*Lingula elderi* Whitf.
Prasopora lycoperdon Vanuxem (rare)	*Bellerophon bilobatus* Sow.
" *hemispherica n. sp.*	*Raphistoma lapicida* Salter.
Zygospira recurvirostris Hall.	*Murchisonia milleri* Hall (typical)
Lingula riciniformis Hall.	*Modiolopsis oviformis* (n. sp.)
" *curta* Hall.	*Tentaculites obliquus* (n. sp.)[1]

Beds VII. These beds are usually darker than the preceding, being often dark blue, with the shales sometimes even black. The latter are commonly brownish, weathering to a dark drab or gray. The whole is about sixty feet thick and composed of thin, irregularly bedded, highly fossiliferous limestones, with thin, shaly partings. After an exposure of several years the slabs are nearly always small, and characterized by their rough nodular surface. They decompose rather rapidly and give rise to the best soils in the state, for it is upon them mainly that the famous blue-grass attains its most luxuriant growth.

These beds are well exposed in the cuts along the C. S. R. R. between four miles south of High Bridge and Burgin, two miles farther south. Also in several cuts between two and a half and five miles south of Burgin, where they again form the surface rock, after having been covered by succeeding layers for perhaps a mile and half. Natural exposures are not common, because of the level lands that have resulted from their uniform disintegration. Some fairly good exposures are seen at Frankfort.

Fossils are very abundant, particularly so the Bryozoa, many

[1]This species is abundant in certain layers. It is about 10 mm. long, 1.0 mm. in diameter, slightly curved, and marked with rounded annulations about 15 to 5 mm., which pass obliquely around the shell.

of which are as yet undescribed. They are generally in a good state of preservation, and so far as observed, never silicified. Those of interest in this connection are:

Stictopora mutabilis Ul.
" *paupera* Ul.
Pachydictya acuta Hall.
Eurydictya multipora Hall's sp.
Ceramoporella sp. (a)
Atactoporella sp. (a)
Prasopora lycoperdon Van.
(typical and very abundant.
Dekayia trentonensis. Ul.
Petigopora petechialis Nich.
Monotrypella multitabulata Ul.
Batostomella ? trentonensis Nich. sp.
Camerella n. sp. (a)
Lingula riciniformis Hall.
" *cobourgensis* Bill.
Bellerophon bilobatus Sowerby.
Cyrtolites compressus Conrad.
Fusispira terebriformis Hall.
Raphistoma lenticularis Hall.
Murchisonia milleri Hall. (typical)
Holopea ventricosa Hall.
" *leiosoma* Bill.
Tellinomya levata Hall.
Lyrodesma planum Conrad.
Conchicolites flexuosum Hall.
Dalmanites callicephalus Green.

(*To be continued.*)

F. V. HAYDEN, M. D., LL. D.

BY E. D. COPE.

Ferdinand V. Hayden, M. D., Ph. D., the well-known geologist, died December 22 at his residence in Philadelphia, after an illness which confined him to his room for over a year and a half.

He was born in Westfield, Mass., September 7, 1829, and at an early age emigrated to Ohio, and was graduated from Oberlin College in 1850. He afterward studied medicine at the Albany Medical College, taking his degree in 1853. He did not practice medicine, but in the spring of the year of his graduation visited the "bad lands" of Dakota on White river in the interest of Prof. James Hall, explored one of the remarkable ancient deposits of extinct animals, and returned with a large and valuable collection of fossil vertebrates. He spent the three following years in exploring the upper Missouri, and his large collection of fossils was partly given to the Academy of Sciences in St. Louis and a part to the Academy in Philadelphia. These collections attracted the attention of the officers of the Smithsonian Institution, and he was appointed, at the suggestion of general J. A. Logan, geologist on the staff of lieutenant G. K. Warren, of the U. S. topographical engineers, who was then making a reconnoissance of the Northwest, and continued

on duty till 1861, when he entered the war as a surgeon of volunteers. He was brevetted lieutenant-colonel for meritorious services at its close.

In 1863 he was elected professor of geology and mineralogy in the University of Pennsylvania, and held that post until 1872, when he resigned on account of the increased labor of managing the survey. In the summer 1866 he made another expedition to the upper Missouri.

The United States geological survey of the territories, under charge of professor Hayden, was commenced in the spring of 1867 and continued until 1879. Ten annual reports of the survey have been published in 8vo, and eight volumes of the quarto final report. Three volumes of the 4to series are not yet published. This survey was the first of those which have been created by Congress for the purpose of determining and recording scientifically the characteristics of the national domain. It was the work of Dr. Hayden, and all other national surveys have been of later origin and more or less similar in character. Those acquainted with the history of this great work, know the persevering energy necessary for its successful establishment and conduct. Dr. Hayden's scientific investigations formed a nucleus from which sprung the noble series of reports and monographs of the survey. He is the founder of our knowledge of the geographical geology of North American from the eastern border of the plains to the Wasatch mountains, inclusive of the latter, thus covering the Rocky mountains from near the Canadian boundary to southern New Mexico. Subsequent explorers have modified his work in details only, and have given it in some respects greater precision, but the grand outlines were first laid down by Hayden. Among his numerous discoveries, that of the Laramie formation is regarded as the most important, since it is of great extent in North America, and scarcely known in any other continent.

At the time of his earlier explorations the aboriginal population of the west was greater than it is now. Dr. Hayden had many adventures with the red men, but none resulted in bodily harm to himself. His occupation as a geologist excited their curiosity, which was generally satisfied by the conclusion that he was not entirely sane. The Sioux gave him the name of

"The-man-who-picks-up-stones-running." On one occasion, while he was engaged in an exploration of the beds of the Laramie formation of the upper Missouri, he was chased by Indians for many miles. When at last they overtook him, they were surprised to find him armed only with the geologist's pick and hammer, and proceeded to search him. They examined the bags which he carried, and turned the fossil bones and shells which they contained out upon the ground. Finding nothing of value to them, they concluded that he was crazy, and left him without harm.

His reports of the exploration of the famous Yellowstone region in 1870 and 1871 induced Congress to set apart by law as a national park three thousand five hundred and seventy-five square miles of the public domain, containing within its limits most of the geysers, hot springs, and other wonders of that region.

Dr. Hayden's views were broad, and he possessed the true scientific instinct. This was perhaps mingled with more restlessness and less patience than is desirable for the closet investigator, but this character admirably adapted him for pioneer work, and for the organization of investigation. As a collector he was unsurpassed, and the material he obtained was the basis of the work of many men, among whom may be especially mentioned, Meek, Leidy and Baird. Hayden's influence was second only to that of Baird's in securing for science the aid and recognition which it has received from the government of the United States.

At the period of his greatest success Hayden was always the same unpretentious and enthusiastic seeker for knowledge. He was singularly free from sordid motives, and he left the service of the government a poor man. The most prominent features of his character were; restless activity, ambition to accomplish a useful career, love of scientific truth, sympathy for unpretentious merit, and a certain flexibility of character which enabled him to adapt himself to his environment more readily than is possible to many men. His charity was lavish, and his affability was unbounded. These characteristics sometimes led persons but superficially acquainted with him to undervalue his merits; but those who knew the place he filled in the economy of Amer-

ican science found these traits more attractive than official formality or self-conscious importance.

He married Miss Emma Woodruff, of Philadelphia, who survives him. He left no children.

EDITORIAL COMMENT.

MURRAY'S THEORY OF THE FORMATION OF BARRIER REEFS AND CORAL ISLANDS.

The Duke of Argyll's paper, *A Great Lesson*, published in the *Nineteenth Century* for September, and in the *Popular Science Monthly* for December, 1887, brings once more into prominence Mr. Murray's explanation of the phenomena of barrier reefs and coral islands. For fifty years the explanation of the phenomena, offered by Charles Darwin, has held its place in the scientific world. Darwin's theory postulates a sudsidence in the Pacific region equal, or approximately equal, to the soundings just outside the reefs, the rate of subsidence being not greater than the vertical rate of reef accumulation. It is on all hands admitted to be a fact that reef-making corals cannot grow at depths greater than twenty or thirty fathoms. Some of the reefs of the Pacific seem to come up from depths of more than two hundred fathoms, and hence it was assumed that, when the corals established themselves in the region, the depth of the floor on which the reef foundations are laid must have been very much less than at present. Even on the land side of barrier reefs the depth of the water is often so great as to be far beyond the limits at which reef-building corals grow. The distance of barrier reefs from the shore varies within wide limits; fifteen, twenty, and even in some instances, seventy miles of open channel intervening. According to Darwin the growth of corals is vertical and the reef-foundations are necessarily laid in shallow water near shore; hence all this space between shore and reef, whatever its width, stretching away along the coast sometimes for hundreds of miles,— often com-

pletely encircling small islands,—represents so much land that has been carried by subsidence beneath the level of the sea. Out in mid Pacific again are smaller reefs similar in all respects to reefs that encircle the smaller islands, but in place of an island each reef surrounds a lagoon or basin of clear, quiet sea-water. These are the atolls or coral islands proper. Darwin's explanation is familiar to all. The corals laid the foundations of the reef around the skirts of an island, but the island has disappeared as a result of subsidence, and its place is now occupied by the enclosed lagoon. Moreover, the lagoon would represent approximately the area of the lost island. Such, in brief, are the explanations proposed by Darwin, and such have been the teachings of geology for nearly fifty years.

The theory of Murray that, according to Argyll, must now supplant the teachings of Darwin, is based on observations made during the voyage of the Challenger. It requires no subsidence. The phenomena, according to Murray, would be the same whether the area were stationary or even slowly rising. Without going into every detail, the explanation would be something like this: Other conditions being favorable, corals will establish themselves over the sea bottom, along shores, out to the twenty or thirty fathom limit. The outermost colonies, however, have an advantage in respect to the food and oxygen brought by the waves. Along the outer limit colonies are therefore more numerous, and at the same time more vigorous, and the reef rises more rapidly than elsewhere. The animals on the outer zone exhaust the sea water of its supplies and the colonies on the inside of the upward growing rim necessarily perish. During the upward growth of the reef fragments, through the action of waves, driftwood and other agencies are continually breaking off from the fragile, branching colonies, and falling down on the seaward side. A talus is thus formed, which, as soon as it reaches the proper hight, is seized as a foundation on which new colonies establish themselves. The new foundation affords special advantages in the matter of nourishment; the seaward colonies thrive while those situated on the inner margin being placed at increasing disadvantage, languish and finally perish. In this way, according to Murray, coral reefs are continually advancing seaward.

The dead coral on the inner portion of the reef is attacked by the solvent action of the sea water and slowly removed.

Deep-sea corals, mollusks, sea-urchins or other agents may assist in building up the foundations on which the reef progresses outward, but the principal source of the material must be fragments broken from the reef itself.

Atolls are explained by the fact that shoals often exist in mid-ocean at depths not incompatible with the growth of reef-building corals. Corals taking possession of such shoals must of necessity construct annular reefs, and the reef once established will grow outward so as to embrace an ever widening area. Solvent action, working upon the dead corals in the rear, causes the dimensions of the old lagoon to keep pace with the widening circle of growing coral.

There is nothing incompatible with known phenomena in the theory either of Darwin or of Murray. Scientists, notwithstanding the absurd charge of the Duke of Argyll, will concern themselves only with ascertaining which corresponds most nearly to the facts. Dana, who has traversed the Pacific region and made personal observations of all the phenomena, presents in his work on Corals and Coral Islands, numerous evidences of subsidence, strongly corroborative of Darwin's explanations. Geike, in his recently prepared text book on geology, states Murray's theory fairly, yet seems to place unshaken confidence in the theory of Darwin.

The magnitude of the operations involved and the length of time demanded by Murray's theory are certainly startling. Imagine a barrier reef, seventy miles from shore and coming up from a depth of 1200 or 1500 feet. The reef began near shore. Little by little it has crept seaward on a foundation of its own fragments. Every inch of progress required the growth and destruction of enough coral to build up a foundation from the bottom to within twenty or thirty fathoms of the surface. At first the depth was not great and the foundations could be easily laid, but during the later history of the reef seaward progress must have been inconceivably slow. The amount of calcareous matter actually secreted by living corals, according to Murray's view, was sufficient to solidly fill all the space between the shore and the reef. Remember too that corals were not working

over all the area at once; that only a comparatively narrow belt is occupied by living corals at any given time, and hence successive, narrow, parallel areas of the entire region had to be conquered and filled up one after another. The amount of calcareous matter dissolved and carried away falls but little short of the amount secreted. The operations, furthermore, are not only of stupendous magnitude, but they certainly increase immeasurably our conceptions of the length of the modern geological period. Here are species and here also are conditions that must have remained practically unchanged since the operations began.

As we said before, geologists and scientists generally will content themselves with one question. Is the theory in accord with demonstrable facts?

ON THE CHERT OF THE UPPER COAL MEASURES IN MONTGOMERY COUNTY, IOWA.

The discussion of the organic origin of chert, by Dr. G. J. Hinde, in the Geological Magazine for October, 1887, suggested the propriety of re-examining the chert in the Upper Coal Measures of Iowa. The chert is particularly abundant in the Upper Carboniferous limestones of Montgomery county, the geological horizon being about the same as that at which Dr. Hinde procured his specimens in Ireland, North Wales and Yorkshire. The chert from the Carboniferous limestones of Great Britain and Ireland proves to be composed largely of sponge spicules, practically unchanged, and Dr. Hinde concludes that it is not a pseudomorph that has taken the place of calcareous matter. Occasionally fragments of crinoids, changed to silica, are found in the British Carboniferous chert, but no foraminifera were observed.

The Iowa Carboniferous chert differs from that examined by Dr. Hinde in being often crowded full of shells of foraminifers belonging to the species *Fusulina cylindrica.* These shells are all completely silicified, and, at least to the extent that they make up the mass, the Iowa chert is pseudomorphic. Microscopic sections were prepared and carefully examined, but no indications of sponge spicules were detected. Examination

with the polariscope shows the structure to be non-crystalline. Prof. Hitchcock, to whom specimens were referred by Dr. Andrews director of the chemical laboratory of the University of Iowa, finds a considerable portion of the chert to consist of "soluble silica." All silica, however, is soluble under certain conditions; and all the facts at present in our possession, point to the conclusion that the chert in the Upper Coal Measures of Iowa was deposited from the solution in sea-water after the limestone beds, with their multitudes of *Fusulina* shells, had been laid down. The process was one of pseudomorphism. Something, we cannot tell what, determined that at certain points in the limestone beds the percolating waters, charged with silica, took into solution the more soluble calcic carbonate and deposited an equivalent amount of silica in its place. Each such point became a center around which the process of exchange proceeded, until masses of chert varying in shape and in dimensions from a fraction of an inch to more than a foot in diameter were formed. The sedimentary particles of the limestone and the calcareous shells of *Fusulina* were involved in a common process.

THE NEW GEOLOGICAL MAP OF EUROPE.

We would like to emphasize the request of Dr. Frazer, secretary of the American committee of the International Congress of Geologists, that American geologists should enable him to report the entire subscription of 100 copies of the geological map of Europe now being constructed by the International Congress. All institutions in which geology is taught in the progressive methods and spirit of the day will subscribe for it, and all others are earnestly advised to.

BULLETIN OF DENISON UNIVERSITY.

We have received the bulletin of the scientific laboratories of Denison University at Granville, Ohio. This is the second volume, and is brought out under the joint superintendence of Profs. Herrick and Cole. It opens with a sketch of the geological history of Licking county, Ohio. This is fol-

lowed by a long list of fossils, with descriptions, from Flint Ridge, and amply illustrated. An appendix consists of a summary of the Carboniferous trilobites and the description of a species which is identified with *Proctus missouriensis* of Shumard, but which the author of the paper has removed to the genus Phillipsia, and has re-named *P. Shumardi.* Another appendix treats of the bryozoans of Flint Ridge and contains reprinted descriptions of the species hitherto found at that locality with several original ones by August Foerste.

Next follows the second part of a monograph on the Clinton group of Ohio, with descriptions, reprinted and original, of the fossils thus far identified by the writer. Mr. Foerste's contribution to the palæontology of the state in this monograph bids fair to be of great value to those who desire to see some progress made in the study of Ohio fossils.

In a different direction is the paper on the determination of the horizontal component of the Earth's magnetic force by L. E. Akins. This is a repetition of the method in use in the University of Glasgow and makes no pretension to originality. Such work is however near enough to geology to be included in this notice.

Part II contains an account of the investigations carried on by Prof. Herrick and two members of his class on the shores of lake Superior during the past summer (1886). They are chiefly lithological and give details of the examination of the azoic rocks in the neighbourhood of Michipicoten bay. This work involves the preparation of numerous thin sections of the rocks in question and of the slides thus obtained many good figures are given.

The rest of this part is made up of an additional contribution to the geology of Licking county and a third installment of Mr. Foerste's monograph on the Clinton group.

Our limits do not permit a longer notice. It is only fair to say in conclusion that the volume is exceedingly creditable to its authors and that it will be well for the cause of true scientific education in Ohio when our colleges produce more of such work. True mental development comes from this and not from ever so thorough and tedious an acquisition of the results of the labors of others.

We regret to learn that the expense of this work has been so largely borne by at least one of the authors, and hope the day will come when original investigation will be regarded as part of the duty of every professor of science and that he will be enabled to do it by the possession of leisure and the necessary instruments.

We must add in conclusion that the work is amply, we may say profusely, illustrated and that the illustrations are good. It may be obtained from the authors at Granville, Ohio.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Is there a Huronian Group? By R. D. IRVING. (Am. Jour. of Sci., vol. xxxiv, Sept., Oct., Nov., 1887). In this well written paper we have evidently the fruits of careful and laborious study. All the statements and inferences are based on an extensive series of patient and painstaking observations made in the field.

The author uses the term group in accordance with the system of nomenclature proposed by the director of the United States geological survey. According to this system the term group would include all the sedimentary deposits of such a division of geological time as has, by common consent of geologists, been called an *age*. Thus we have a Carboniferous age, a Devonian age, a Silurian age, etc., and the stratified sediments that accumulated during the three ages give us the corresponding Carboniferous, Devonian and Silurian *groups*.

Using the term *group* as thus defined, and limiting the observations first of all to the original or typical Huronian as "mapped by Logan on plate three of the atlas to the Geology of Canada, 1863," the author proceeds to answer the inquiry whether "there can be carved off of the upper portion of the great complex which has been called Archæan, a series of *Huronian* rocks; a series entitled -- by structural and genetic separateness, by clastic origin, by largeness of volume, and by the being made up by subordinate divisions of the formation rank—to the rank of a group, i. e., to a rank equal in classificatory value to the Cambrian, Silurian, etc." The results of the author's observations lead him to return an affirmative answer to the inquiry, and he therefore proposes to establish a Huronian group that shall have the same rank as the Cambrian, Silurian, Devonin or Carboniferous.

Some of the facts presented and conclusions arrived at in the paper are best expressed in the words of the author's synopsis of its contents.

"Throughout the region stretching from the north shore of lake Huron

westward to the Mississippi river, in central Minnesota, there is recognizable the following order of succession, beginning below:

"(1) The great basement or Laurentian complex of gneiss, granite and crystalline schists; as to whose further divisibility no opinion is now offered. This is separated by a great discordance from

"(2) The Huronian, a detrital iron-bearing series. A further discordance severs this from

"(3) The Keweenawan series of interleaved detrital and eruptive beds. This series again is entitled to the group rank. Above the Keweenaw series, and separated from it by yet a third great discordance,

"(4) The *Potsdam*, or Upper Cambrian sandstone."

Professor Irving proposes to limit the term Archæan to the crystalline rocks below the Huronian. The Huronian and Keweenawan groups, together with any other groups now known, or hereafter discovered, to lie between Archæan and lower Palæozoic, or Cambrian, he would erect into a *system*, equivalent in rank to the Palæozoic or Mesozoic systems; and to this new system he proposes to apply the appropriate non-committal *Agnotozoic*, a term first proposed by president T. C. Chamberlin.

Sand-boulders in the drift, or sub-aqueous origin of the drift in central Missouri. By J. W. SPENCER. (American Naturalist, vol. xxi, October, 1887.) This is the paper read by professor Spencer before the New York meeting of the American Association. The sand-boulders described were found in the surface deposits at Columbia, Missouri, within a few miles of the 39th parallel of latitude. Columbia is the seat of the state university of Missouri, and it was in making excavations for foundations of new buildings at the university that sand-boulders were exposed.

The sand-boulders are masses of coarse sand, varying greatly in size, the largest one mentioned being thirty feet long and six feet thick. As in ordinary rock-boulders, the angles of the sand-boulders are rounded as if by attrition. They lie in fine clay containing but little sand, and are sharply defined from the surrounding matrix. Planes of stratification show that the masses of sand were derived from some sub-aqueous deposit; and the stratification of the clay in which they are imbedded, leads the author to conclude that it too is subaqueous. Professor Spencer suggests that "these deposits were probably made in a shallow arm of the sea, cut off by the Ozark ridge rising a few hundred feet higher; yet the waters may have been either brackish or even fresher—as the gulf of Obi today, owing to the amount of fresh water pouring into it; and not to a glacial lake."

We are to conceive of a condition of things in central Missouri similar to what now obtains along sandy shores, particularly in shallow bays north of the arctic circle. During the cold winters floe-ice formed around the margins of this "arm of the sea," and into the lower surface of the floe, the stratified sand was frozen to a depth of several feet. In the spring the sand and ice, incorporated into one mass by the agency of frost, was broken up and floated away; the frozen sand, losing its angles and overcoming the buoyancy of the ice, as the latter was diminished

by melting, settled to the bottom to be covered up by layers of fine clay. Torrents from melting glaciers, coming down from the land areas to the north, were the bearers of the material composing the stratified clay.

Usually the sand-boulders lie horizontally, but occasionally they are found thrown upon their edges. Sometimes they show signs of having been jammed and broken as if in an ice-pack.

The facts are significant and reveal a state of things that we have every reason to believe was repeated whenever there were bodies of water contiguous to the southern limits of the great glacier.

On the organic origin of the chert in the Carboniferous limestone series of Ireland and its similarity to that in the corresponding strata in North Wales and Yorkshire. By DR. GEORGE J. HINDE. (Geological Magazine, Decade III, vol. iv, October, 1887). This paper was read before the British Association at its Manchester meeting last summer. It is a continuation of the discussion relating to the Carboniferous chert, begun by Messrs. Hull and Hardman, in a joint paper published in the scientific transactions of the Royal Dublin Society, 1878.

Messrs. Hull and Hardman, after chemical and microscopic examination of the chert from the Carboniferous rocks of Ireland, reached the conclusion that the chert was of inorganic origin, that the silica, held in solution in percolating water, replaced portions of the limestone by a process of pseudomorphism, and that there was absolutely no evidence that the chert originated directly or indirectly in such organic products as sponge spicules, diatoms or polycistines.

Prof. Sollas in 1881 re-examined some of the microscopic sections prepared by Prof. Hull in the course of his investigation, and pronounced certain rod-like or tube-like structures that Prof. Hull seems to have taken for minute crinoid stems, to be nothing but spicules of sponges. Dr. Hinde visited numerous localities in Ireland for the purpose of examining and collecting Carboniferous chert. Among others the typical localities from which Prof. Hull's material had been derived, were examined and specimens secured. Microscopic sections were prepared from specimens from every locality visited, with the result that sponge spicules were more or less conspicuous in every section. Ordinarily the rock is crowded full of spicules. Fragments of brachiopod and entomostracan shells and a few crinoid plates were detected, but no foraminifera.

Respecting the chert from the Carboniferous strata of North Wales and Yorkshire Dr. Hinde points out that in all essential features, lithologically and chemically, it is identical with the Irish Carboniferous chert, and then adds: "The organic nature of the English and Welsh Carboniferous chert, as produced from sponge-remains, is far more distinctly shown than in the case of the Irish beds, for the spicules are much better preserved, and the beds have been less altered by fossilization."

The profusion of sponges during the later Carboniferous, in the area now occupied by Great Britain and Ireland may be inferred in the statement that "In some of the Yorkshire areas there are beds of chert

18 feet in thickness, without a break, and in North Wales there is a continuous series 350 feet in thickness, without the intervention of limestones.

[See editorial note on the Carboniferous chert of Iowa on another page of the present number of the GEOLOGIST.]

Annual report of the department of mines, New South Wales. By HARRIE WOOD, Under Secretary of Mines. (A Government document of New South Wales, Sydney, 1887.) This volume contains the administration and progress reports of the department, including those of the geological survey, and statistics of all mining operations in the colony. Mr. C. S. Wilkinson, the geologist in charge, announces the discovery of fossils of the Triassic (thoracic plates of *Mastodonsaurus*) and of a large fossil shell, from the Hawksbury sandstone. The latter is figured and named by Mr. Robert Etheridge, jun., *Tremanotus maideni.* It has a resemblance to *Tremanotus alpheus* Hall, from the Niagara group.

Geology of the Vegetable creek tin-mining field, New England district, New South Wales; quarto, with maps and sections. By T. W. EDGEWORTH DAVID. (A publication of the geological survey of New South Wales, Sydney; C. S. Wilkinson, geological surveyor in charge.) The discovery of tin in New South Wales was first announced by Rev. W. B. Clarke, in 1849. In 1885 the output of tin amounted to 2,505 tons. Continued prospecting of surface tin gravels led on by degrees to the discovery of the tin veins. The shallow workings produced their largest yield in 1881, since which time their productiveness has constantly declined. The "deep leads" which were first worked in 1883, now yield far more ore than the shallow gravels, and will probably continue to form a valuable source of stream tin for many years to come. The tin veins have not yet been fairly tested, and it would be premature to predict their value and permanence. The age of the "deep leads" is regarded as early Tertiary, determined by fossil plants identified by Baron von Ettingshausen. The age of the intrusive tin-bearing granites is thought to be Permian. No granites in the colony have appreciably disturbed the Triassic rocks, whereas there are intrusive granites newer than the Carboniferous. The age of the granites is, however, not regarded as well established. Laterite is classed with basalt. It is found to be most largely developed near the highest points of the sheets of lava, but it varies in structure and composition, some specimens being more allied to a sedimentary formation than to a volcanic. The paleozoic rocks are considered Upper Silurian.

Preliminary paper on the driftless area of the upper Mississippi valley. By T. C. CHAMBERLIN and R. D. SALISBURY. Pages 190-322; plates xxiii-xxix. (Accompanying the sixth annual report of the director of the United States geological survey.)

Under the thorough and fruitful discussions of this paper, the driftless area and its environs contribute much to our knowledge of the ice age, especially in regard to the preglacial topography and surface deposits, glacial planation and the average thickness of the drift, relative age of

its different portions adjoining the driftless area, conditions attending the deposition of the loess, the influence of gravitation toward the ice-sheet to change the levels of lakes and the rate of descent of streams, and the elevation of the district during the chief interglacial epoch. No brief review can even mention the many directions in which important researches have been made by the authors in this work.

The driftless area, lying chiefly in southwestern Wisconsin, but including also the northwest corner of Illinois, and reaching 10 to 40 miles west of the Mississippi into northeastern Iowa and southwestern Minnesota, has an extent of 200 miles from north to south and a width of about 100 miles. Thence east to the Atlantic, north to the Arctic ocean, and northwest to the Pacific, the continent is overspread by the glacial drift, which also covers a width of 340 miles on the west and about 225 miles in its narrowest portion on the south. Cambrian and Silurian formations of sandstone, limestone and shale extend from the driftless to the adjoining drift-covered country, which also are nearly alike in their average hight. The driftless area therefore, with no till, boulders, nor effects of glaciation, such as are found on all sides of it, must be nearly the same in its contour and superficial deposits as the surrounding region was before the glacial period.

The most noteworthy element in the contour of the driftless area is its isolated cliffs of the nearly horizontal limestone and sandstone strata, spared in the process of subaërial erosion, and standing forth like castles, towers, and pillars. In many places the valleys of streams are bordered by similarly precipitous walls of rock. The Mississippi has cut a valley 300 to 600 feet deep and from one to seven miles wide; and the valley of the Wisconsin river averages 375 feet in depth and three miles in width. Concerning the time when this sculpturing of the surface was effected, the authors conclude that the driftless area was a low lying tract until the Tertiary age, and hence was subject to but slow and slight erosion, and that much of it was accomplished so late as the closing stages of the Tertiary age and the transition period to the glacial epoch.

On the greater part of the driftless area east of the Mississippi the surface deposit is residuary earth, mostly very fine clay, left from the erosion of the overlying strata. Its average depth is about seven feet, being far less than the average thickness of the drift upon the surrounding region. On the part of the driftless area west of the Mississippi and that closely bordering this river on its east side, the residuary earth is overspread by loess, a fine silt of glacial origin, deposited in a lake or broad river with very slow current, which was continuous southward, as shown by the extension of the loess, to the lower part of the Mississippi valley. The authors find no reason to believe that a lake, such as might be attributable to the barrier of the ice-sheet confluent on the south, covered the whole of the driftless area during any considerable time.

The drift immediately adjoining the driftless area presents three phases, similar to those which characterize the southern border of the great drift sheet of the continent. On the east the Kettle moraine, ris-

ing in conspicuous hills and ridges, forms the boundary along a distance of about eighty miles; on the northeastern and northern sides of the driftless area its boundary is a drift sheet gradually attenuated and terminating in a thin edge instead of a ridged moraine; and on the west border there is a tract over which there are only scattered drift pebbles, succeeded westward by such an attenuated drift sheet. The morainic border belongs to the later part of the glacial period, when the streams of the driftless area had slopes similar to those of the present time, so that beds of gravel and sand, washed from the melting ice-sheet, were deposited along their valleys. The glacial flood-plains have been mostly removed by post-glacial erosion; and their remnants form terraces at hights from 50 to 100 feet above the Mississippi, Wisconsin and Chippewa rivers.

Grand topographic features of the region north and east of the driftless area, where the Keweenawan range of highland rises between the deep basins of lakes Superior and Michigan, are considered the chief cause of the exemption of this region from glaciation, as had been pointed out by Prof. N. H. Winchell and Prof. Irving.

From their study of the driftless area and the bordering drift, the authors deduce the following sequence of events in the glacial period.

1. The ice-sheet in its maximum extent reached from the north around both sides of the driftless area and coalesced south of it. To this stage is referred the attenuated drift sheet which forms the border on the southeastern and northern sides of the area, and also the pebbly border on its west side, which reaches beyond the attenuated drift there and seems to be due to floating ice in a marginal lake.

2. Recession of the ice-sheet permitted the growth of trees and the formation of peat-bogs.

3. By a re-advance of the ice, a mantle of till deeper than the earlier one was deposited, burying trees and peat beneath it; and the loess was washed down from the melting ice-fields into a lake-like river upon their border.

4. A long period of freedom from glaciation appears to have followed the epoch of the deposition of the second till and loess, involving extensive erosion and the lifting of the upper portion of the Mississippi basin to the extent of 800 to 1,000 feet. The evidence of this is found in the low altitude and gentle slopes which must have prevailed when the loess was deposited along the great streams from Nebraska to Indiana and southward to the Gulf; and in the higher elevation which made it possible for the later glacial streams to flow with rapid, pebble-carrying currents at altitudes 700 feet below the summit of the loess.

5. Following this chief interglacial epoch came the incursion of ice which pushed up at its edge the Kettle moraine and sent coursing down through the valleys its gravel-bearing streams, filling them and spreading out broad flood-plains.

6. There closely followed a succession of stages of retreat of the ice-sheet, interrupted by times of halt and partial re-advance.

7. Subsequent to the cessation of the glacial floods, the streams carved the flood-plains into terraces.

(1) *Fulgurite from Mt. Thielson, Oregon* By J. S. DILLER. (From the American Journal of Science, Oct. 1884.)

(2) *Peridotyte of Elliot county, Kentucky.* By J. S. DILLER. (Bulletin No. 38 of the U. S. geological survey.)

(3) *Notes on the geology of northern California.* By J. S. DILLER. (Bulletin No. 33 of the U. S. geological survey.)

(4) *The latest volcanic eruption in northern California, and its peculiar lava.* By J. S. DILLER. (From the American Journal of Science, Jan., 1887.)

In (1) the peculiar product of lightning on a mountain peak of hypersthene-basalt is analyzed both chemically and microscopically. The fulgurite is formed by the fusion of the groundmass of the rock. A transverse section through the wall of the glassy tube revealed under the microscope three bands of varying effect of fusion. The inner band, the most perfect fulgurite, a light coffee-brown glass, was cooled so suddenly that it exhibits an entire absence of all crystallites and microlites, a character which the author thinks may serve to distinguish it from other natural glasses such as hyalomelane and obsidian. In the central belt a fluidal banding parallel to the length of the tube is apparent, in which are preserved more or less evident remnants of the original crystals of the basalt. The third belt consists of the unaltered rock.

In the description of the Kentucky peridotyte Mr. Diller gives the mineral composition and structure, its relations and origin, its chemical composition and its age. He concludes that it is closely related to dunyte, such as occurs in North Carolina. It contains olivine in well defined crystals, pyrope and ilmenite, the former with a fibrous border of secondary biotite. The olivine is much changed to serpentine. The dike occurs in rocks of Carboniferous age, of which it includes fragments, and from which it has received endomorphic effects in the form of a sphærolitic structure. Mr. Diller's first account of this peridotyte appeared in the Am. Jour. Sci., Aug., 1886.

In bulletin No. 33 are brought out some important generalizations respecting the Coast and Sierra Nevada ranges in northern California, viz: (a) The limestone among the metamorphic rocks of the Coast and Sierra Nevada ranges is of Carboniferous age. (b) The northern portion of the Sierra Nevada range, like that of the great basin, is composed of tilted orographic blocks separated from one another by great faults. (c) The greater portion of the range is formed by one of these blocks, with a short abrupt slope toward the great basin, and a long gentle slope in the opposite direction. (d) The displacements by which the Sierra Nevada range was separated from the great basin probably began about the close of the Tertiary, and may be yet in progress. (e) A large portion of the auriferous slate series is apparently older than the Carboniferous limestone. (f) During the Chico epoch a large part of the region now occupied by the Coast range was an island, separated by a wide strait from

the continental mass to which the Sierra Nevada range belonged, which strait has since been filled by the lavas of the Lassen's peak volcanic ridge. (g) As far as is definitely known the Cascade range was not represented by a ridge of metamorphic rocks corresponding to the Sierra and Coast ranges, but belongs rather to the great volcanic field which now occupies the area once depressed between the Cretacean island and the continent. These conclusions are based on the field-work of three seasons under the general supervision of Capt. C. E. Dutton, who states that he is entirely in accord with Mr. Diller's results.

The great "cinder cone," near Snag lake, about ten miles northeast of Lassen's peak in northern California is the seat of the latest volcanic eruption in that region. It rises 620 feet above the lowest portion of its base, rising at an angle of 30° to 35° and consists of small scoria and lapilli. The lava field surrounding it extends over about three square miles and consists of rough blocks of quartz-basalt in which Mr. Diller considers the quartz to have originated in the magma itself. The field of volcanic ashes extends beyond the lava field from ten to twelve miles in all directions and sustains the heaviest pine forests. At a quarter of a mile from the "cinder cone" the layer of ashes was found seven feet thick. This gradually thins out to the border of the field. There are numerous dead trunks of pine that rise from the underlying original soil through the ash layer, evidently killed at the time of the eruption. The ash and the cinder cone are considered products of the same eruption and somewhat older than the quartz-basalt with which they are associated.

Ovibos cavifrons from the Loess of Iowa. By W. J. McGEE. (Am. Journal of Science, vol. xxxiv, Sept., 1887). Mr. McGee's paper relates to a specimen of the extinct musk-ox of North America, which was found during the summer of 1887, in loess deposits at Council Bluffs, Iowa. The "find" consisted of a very perfect cranium with horn-cores complete, and a portion of the superior molars still in place, half the lower jaw, the atlas and portions of other vertebræ, one femur, and a number of other bones more or less fragmentary. All these specimens are now in the cabinet of the State University of Iowa.

Specimens of *Ovibos cavifrons* were previously known from Fort Gibson, Ind. Ter., St. Louis, New Madrid and Benton Co., Missouri, Trumbull Co., Ohio, Big Bone Lick, Ky., and (probably) "the frozen cliffs of Eschscholtz bay."

The *Ovibos cavifrons* resembles structurally its northern congener, *Ovibos moschatus*, and its habits were undoubtedly very similar. Leidy expresses the opinion that it was clothed with a long fleece. The Council Bluffs discovery is therefore significant for two reasons. First, "it adds an important link to the already strong chain of evidence as to to the climate of the loess period;" and second, "it greatly extends the applicability of *cavifrons* as a criterion for correlating deposits of widely diverse genesis in widely separated localities."

The author enumerates the palæontologic evidence of refrigeration during the loess period, and regards the Council Bluffs specimens as affording the strongest possible support to the evidence previously accumulated. The New Madrid specimen of *cavifrons* was from the Port Hudson beds of Hilgard, a peculiar deposit found below the mouth of the Ohio and indicative of submergence of the lower Mississippi valley. The Fort Gibson specimen comes from "a puzzling superficial deposit found in Missouri, Kansas, Indian territory, eastern Texas, and Arkansas, which seems to be a slack-water deposit laid down in the water ways of the region during the Port Hudson submergence." The Kentucky specimen comes from just beyond the margin of the drift region, while the specimens from Council Bluffs are found well within the glaciated area.

During the culmination of the glacial conditions of the drift period it would seem that an arctic fauna, embracing the musk-ox, reindeer, hairy elephant and other northern species, was forced as far south as the latitude of Arkansas and the Indian territory.

Sixth annual report of the state geologist, for the year 1886. Transmitted to the Legislature March 1, 1887. By Prof. JAMES HALL. This is a pamphlet of 70 pages, illustrated by eight plates and two maps. There are two papers by S. G. Williams—one on *the Lower Helderberg rocks of Cayuga lake*, and the other on *the Tully limestone, its distribution and its known fossils*. A map illustrating the distribution of the Tully limestone in central New York, accompanies the second paper.

A paper on *Annelid teeth from the lower portion of the Hamilton group and from the Naples shales of Ontario county, N. Y.*, is by J. M. CLARKE, and constitutes a valuable supplement to the work done by Dr. Hinde in the determination of the oral armature of the so-called *Conodonts*. The difficulties attending the specific determination of these minute fossils are fully recognized; and timely warning is given to the effect that "only in the correlated teeth of the opposite sides of a given jaw is there any marked similarity, while the different pairs and the unpaired or radular teeth, constituting the masticatory apparatus, widely vary,"—a warning that we trust will be heeded by our altogether too industrious species makers. The paper is illustrated by a plate containing twenty-nine figures of those curious and interesting forms.

There is a notice of the discovery of a fossil tusk belonging, probably, to the skeleton of a young elephant; a note and map on the distribution of the *Dictyospongidæ*, and a note on the discovery of an elk in the town of Farmington, Ontario county.

The longest paper in the report, by Prof. JAMES HALL, embraces *descriptions of Fenestellidæ of the Hamilton group, of New York.* The paper is accompanied by seven plates, and describes and illustrates a number of species of the genus Fenestella. The recently issued sixth volume of the Palæontology of New York, on account of the limitations placed upon the number of plates it could contain, does not embrace the *Fen-*

estellidæ of the Hamilton, and hence the species described in this report are not included among the species contained in that volume.

It would seem as if the stock of specific names was running low when an author as fertile in invention as professor Hall is compelled to use names for two distinct species, so similar in sound as *Fenestella quadrangularis*, an Upper Helderberg form, and *F. quadrangula*, a species from the Hamilton. *Fenestella perundata* and *F. perundulata*, are two others that are likely to be confusingly similar.

NEW PUBLICATIONS.

1. State and Government reports.

Mineral resources of the United States. Calendar year 1886. David T. Day, 8vo., 813 pp., price 50c. *U. S. Geol. Sur., Washington.*

Report on the progress of the Kentucky geological survey for the years 1886 and 1887. John R. Proctor. Royal octavo, 28 pp. *Frankfort, Ky. Robert Clarke and Co., Cincinnati.*

Annual report of the geological survey of Arkansas for 1887. John C. Branner. 8vo., 15 pp. *Little Rock.*

Annual report of the geological survey of Pennsylvania for 1886. J. P. Lesley, state geologist. Part II. Report on the oil and gas regions, by John F. Carll. Report on the composition and fuel value of natural gas, by Francis C. Phillips. 8vo., 918 pp. *Harrisburg.*

Geology and mining industry of Leadville, Colorado, with an atlas. Samuel Franklin Emmons. 4to., pp. 770; numerous plates and text illustrations. Monograph xii of the *U. S. Geol. Sur., Washington.*

Sixth annual report of the state geologist, for the year 1886. James Hall. 8vo., pp. 70, and seven plates of fossils. *Albany.*

Geological and Natural History survey of Minnesota; 15th annual report. N. H. Winchell. 8vo., pp. 496. Two colored geological maps and numerous text illustrations of the structure of the crystalline rocks. *St. Paul and Minneapolis.*

2. Proceedings of Scientific Societies.

Transactions of the 18th and 19th sessions of the Kansas Academy of Science, 1885 and 1886. Vol. x. 8vo., pp. 154; illustrated. *Topeka.*

3. Papers in scientific journals

In the January No. of the American Journal of Science. The speed of propagation of the Charleston earthquake. *Newcomb* and *Dutton*. History of changes in the Mt. Loa craters. Pt. I. Kilauea, *Dana*. The analysis and composition of tourmaline, *Riggs*. On the different types of the Devonian system in North America, *Williams*. On the law of double refraction in Iceland spar, *Hastings*. New genus of Sauropoda and other new dinosaurs from the Potomac formation, *Marsh*. Notice of a new fossil Sirenian from California, *Marsh*.

In the January No. of the Canadian Record of Science. The distribution and physical and past geological relations of British North American plants, *Drummond.* On the basal series of Cambrian rocks in Acadia, *Matthew.* The prairies of Manitoba, *Drummond.*

4. Excerpts and individual publications.

Note on fossil woods and other plant remains from the Cretaceous and Laramie formations of the western territories of Canada. Sir William Dawson. Read May 25, 1887. *Trans. of the Roy. Soc., Canada.*

Irrigation in Nebraska. Lewis E. Hicks. *Bulletin of the Agr. Exper. Sta. of Nebraska.*

Preglacial man in Ohio. G. Frederick Wright. Fort Hill, Ohio, H. W. Overman. *Reprints from the Ohio Archæological and Historical quarterly, Dec., 1887.*

Section of the lower Devonian and upper Silurian strata in central New York, as shown by a deep well at Morrisville. Charles S. Prosser. *Proceedings of the A. A. A. S., 1887.*

The upper Hamilton of Chenango and Otsego counties, N. Y. Charles S. Prosser. *From the proceedings of the A. A. A. S., 1887.*

The construction of maps in relief; illustrated. John H. and Ed. B. Harden. *Trans. Am. Inst. mining engineers, July, 1887.*

On the discovery of a fossil bird-track in the Dakota sandstone. Prof. F. H. Snow. *Trans. Kans. Acad. of Science, vol. x.*

5 Foreign publications.

Geology and Petrology of St. Abb's Head. Prof. J. Geike. *Proceedings of the Royal Society of Edinburgh.*

Annual report of the department of mines, New South Wales, for the year 1886. Harrie Wood. Small folio; pp 206: geological maps and plates; reports of the geological surveyor, aud numerous subordinates. *Sydney.*

Geology of the Vegetable creek tin-mining field, New England district, New South Wales, with maps and sections. T. W. Edgeworth David, under C. S. Wilkinson, geological surveyor in charge. 4to, pp, 169. *Sydney.*

CORRESPONDENCE.

Brown Hematite in Allamakee county, Iowa. I have several times this fall visited the "iron mine" of Allamakee Co., and thinking that a brief description might be of interest to you, I write you this letter.

This deposit of iron ore is located on secs. 17 and 20, township 98 north, range 5 west, 5th P. M., about two and a half miles north of Waukon, the county seat of Allamakee Co. It lies on the divide between the Upper Iowa river on the north, and a small creek called Village creek on

the south. The larger part of the body of ore underlies a rounded hill or spur of the divide lying between two ravines tributary to the Village creek. The top of this hill at its highest point is slightly higher than the general level of the divide. As far as can be ascertained, the deposit has an area of about 300 acres and an average depth of thirty feet. The ore is a mass of concretionary brown hematite boulders, packed so closely as to form an almost solid ledge, the interstices and cavities being filled with a red ferruginous clay.

This ore lies upon the undisturbed blue limestone which forms the lowest and oldest deposit of the Trenton epoch. I say undisturbed, for wherever a shaft has been sunk through the ore to the underlying limestone, it has invariably been found in its normal position of an almost dead level. I might remark here, that, although I have traveled over every part of this country, I have never seen any fault or tilting of strata or any other indication in any of the formations exposed of an upheaval or disturbance of any kind.

As the Trenton limestone thins out and disappears (in Allamakee Co.,) on the upper part of the north slope of the divide between the Upper Iowa river and Village creek, it can not have a thickness under the ore bed of more than sixty feet. This limestone lies conformably upon the St. Peter sandstone, which outcrops on the tops of all the higher ridges in the north part of the county. It is worthy of notice that this sandstone is everywhere, as exposed in this section, much colored by oxide of iron, and, in a few places, a thin layer of very good ore is found in the upper part of it.

Immediately overlying the ore is a thin stratum of small drift gravel, such as is found in most parts of this county overlying the Trenton, then the usual yellow clay subsoil found in this section. This subsoil, the gravel, and the black surface soil are the only deposits overlying the iron. In no place do they exceed a thickness of ten feet, and should the deposit ever be worked this will make the operation of stripping very easy and cheap.

Some of the upper boulders of ore are composed of very small drift gravel cemented together into a solid mass by the iron; others again are thickly encrusted with these small pebbles. On the occasion of one of my visits there, last fall, I picked up several pieces of ore in which were imbedded well-preserved specimens of Trenton fossils.

A number of assays of the ore have been made and none of them showed less than fifty per cent. of iron, the highest being sixty-four per cent.

ELLISON ORR.

Postville, Iowa, Dec. 15, 1887.

A crystalline rock near the surface in Pawnee Co., Neb. During the past summer a rock of no little interest was brought to light in a boring by the Rock Island & Pacific railroad company in Pawnee Co., Neb. The surface formation is Carboniferous. For 532 feet there is an alter-

nation of shales, red and black, and magnesian limestone. At this depth however, a change begins and at 552 feet a distinctly *crystalline* rock is encountered. Much of it is flesh red but this color is not uniform. It is quite hard, being about six in the scale of hardness. The chief ingredient is feldspar with moreover macroscopic and microscopic particles of hornblende or pyroxene and hematite. The nature of the supericumbent rocks, together with the slight depth at which this rock was found make it quite an interesting subject for further study.

F. W. RUSSELL.

Lincoln, Neb.

The salt well at Lincoln, Neb. The 19th session of the Nebraska Legislature, in 1885, passed a law providing for the sinking of an experimental well near Lincoln. Owing to divers causes the work was not begun until March, 1886. The main object in view was to obtain either rock salt or strong brine, the boring being made on one of the salt marshes of the state. For 205 feet the material was an alternation of sand and gravel. One or two flows of brine were encountered, but of low strength. At 205 feet the best brine was found, testing 35 degrees strength, and inexhaustible. Rock was found immediately under this. From this point downward until about 1100 feet there were slates, shales limestones and sandstones, each stratum of no very great thickness. Red shales and sandstones were quite abundant. Some of the limestone was quite cherty. At 600 feet a fine flow of artesian water was reached which rose over 45 feet above the surface when piped. It was brine of low quality. At 828 feet another flow was encountered, which was a little stronger in quality and made a visible increase in quantity. Nothing now was found until the depth of 942 feet was reached when four inches of coal were passed through. At the time of the sinking strong hopes were entertained of finding a profitable seam after this one was found, but they were not realized. At 1100 feet, or thereabouts, the first magnesian limestone was met, and it was the chief rock onward to nearly 2000 feet. Here was found a sandstone very fine in grain and even in texture. Passing onward one finds magnesian limestone and red sandstone; this last very hard in some places. The work was stopped in this same red sandstone, at the depth of 2463 feet. The boring ceased only on account of a technicality in the law, which made the funds for the purpose unavailable after a certain time. The drill hole was left in excellent condition, however, and there is every reason to believe that the coming Legislature will make arrangements for the continuance of the work 500 or 1000 feet further.[1]

F. W. RUSSELL.

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[1] We are assured that the final report of Mr. B. P. Russell, upon this well, will soon appear. Mr. Russell was appointed by the board of Public Lands and Buildings, to superintend the boring, and his report will be

Additions to the minerals of Minnesota. While engaged in making investigations in northern Minnesota for the state geological survey during the past season two or three minerals were observed that, I think, have not been hitherto reported from that state.

Aragonite in rectangular masses composed of many parallel orthorhombic prisms, all the prisms in the same mass having an equal length, was found in Cretaceous shale on the Little Fork river near the Bois Fort Indian reservation.

Long, thin-bladed crystals of cyanite of a grayish-blue color were found penetrating mica schist in Twp. 70-21, on Rainy lake.

Quartz in fine grains and mica in minute shining scales occur in close intermixture; the whole having a feathery radiated structure and existing in masses of various sizes and shapes in the coarse granite at the east end of Rainy lake. Tourmaline crystals were also noticed.

H. V. WINCHELL.

Ann Arbor, Jan. 10, 1888.

PERSONAL AND SCIENTIFIC NEWS.

MESSRS. CHARLES WACHSMUTH AND FRANK SPRINGER are engaged in the preparation of a work on Crinoids more elaborate than anything they have yet attempted. Their *Revision of the Palæocrinoidea*, a work recently completed, has given these authors an enviable place among palæontologists at home and abroad. The new work, which will bring them even greater honor, will be a complete monograph of the palæocrinoidea of the United States and Canada. All known species will be amply illustrated, redescribed, and properly classified. The principal museums and collectors, with the most gratifying liberality, have sent their type specimens of species and genera for examination and use in the preparation of the monograph. With even greater liberality museums and collectors are placing their undescribed species at the disposal of the authors. The drawings and descriptions will therefore be made almost exclusively from the specimens, and not from published figures. There will be at least one hundred new species described in the work, and several new genera. The crinoids will be arranged, not by formations, but by genera and families, so that the

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received with great interest on account of the depth of the well and its remoteness from any similar boring. The fact that no crystalline rocks were encountered in descending 2463 feet makes the discovery of such rocks in Pawnee county at the depth of 550 feet the more remarkable. Ed.

species of each genus and the genera of each family will be placed side by side. Tables of the families and genera will be given with the descriptions. The work is well under way. The preparation of the manuscript is well advanced, and eleven large quarto plates that are certainly unsurpassed by anything heretofore published, are already finished.

THE KEOKUK (IOWA) SCIENTIFIC SOCIETY, lately organized, will be occupied in developing the "Keokuk beds." It includes among its members some whose researches have already received national recognition. The president is professor C. H. Gordon and the secretary is E. J. Unger.

DUPLICATES OF THE FLORA OF THE DAKOTA GROUP. We are informed by the chancellor of the University of Kansas that the new "Snow Hall of Natural History" is possessed of numerous duplicates of the flora of the Dakota group, which are offered for sale with the view of obtaining funds for further collections. We understand that the specimens are in an admirable state of preservation. The entire series consists of seventy-five species, of which thirty-five are new to science. All have been determined by Lesquereux, and they are mostly his species. Information may be obtained of Dr. F. H. Snow, Lawrence, Kansas.

A NEW JOURNAL. THE AMERICAN ANTHROPOLOGIST is announced to be begun as a quarterly by the anthropological society of Washington. The committee of the society under whose direction the work will appear, are Prof. J. Howard Gore, Thomas Hampson, W. H. Henshaw, Prof. O. T. Mason, Dr. Washington Mathews, S. V. Proudfit and Col. F. A. Seely.

THE TRENTON LIMESTONE AS AN OIL FORMATION. A recent letter from professor Edward Orton, of Columbus, Ohio, makes known the important point which he has lately made, that the Trenton limestone is an oil or gas rock only when it is a dolomyte; that this phase of the rock is superficial; that it extends through northwestern Ohio, northern Indiana and probably through Michigan; that it is in the main filled with salt water, but that in favored portions oil and gas are found. The Trenton limestone in its normal or ordinary constitution is in no sense a gas rock.

AT THE ANNUAL MEETING of the American Society of Naturalists, held at New Haven Dec. 27th-29th, the following geological papers were read. *The volcanoes of Kilauea*, by Prof. J. D. Dana; *A simple method of measuring the thickness of inclined strata*, by Mr. C. D. Walcott; *Improved machinery and appliances for cutting sections of rocks and fossils in any desired planes*, by professor William B. Dwight; *The educational value of micropetrography*, by professor Geo. H. Wil-

liams; *Instruction in mineralogy and structural geology in the Massachusetts Institute of Technology*, by professor W. O. Crosby.

IN SCIENCE FOR DEC. 30, 1887, we find a description of Snow Hall of Natural History, at Lawrence, Kansas, accompanied by an extra sheet giving a perspective view of the building and floor plans of the four stories including the basement. Snow Hall was erected to serve as a Natural History building for the University of Kansas. The state Legislature appropriated fifty thousand dollars for the purpose in 1885; and the building was completed, formally named and dedicated on Nov. 16th, 1886. The name is given in honor of the venerable professor F. H. Snow whose connection with the University dates from its foundation in 1866.

The building seems particularly well adapted to the purpose for which it was designed. In the basement is a large laboratory for elementary botany, a taxidermist's workshop, a biological laboratory, and rooms for storage and other purposes.

The geological collections are displayed in a large museum on the first floor, and on the same floor conveniently situated with reference to the museum are the geological laboratory, and a workroom for the curator of geology. The general lecture room is on the same floor.

The second floor contains separate rooms for the entomological, general zoölogical and botanical collections, together with appropriate zoölogical and botanical laboratories and workrooms. On the third floor there are anatomical and photographical laboratories, an anatomical museum, store rooms and an osteological workroom for the preparation of material. Kansas University is to be congratulated on her splendid equipment for carrying on work in geology and natural history.

THREE OR FOUR YEARS AGO the quarrymen at Le Grand, Marshall Co., Iowa, exposed a thin layer that in places is crowded full of interesting and most beautiful crinoids. The quarries are opened in the Kinderhook limestone, the lower part of the Subcarboniferous formation, and have been worked for a great many years. The crinoids occur in a bed of calcareous shale and are in a most perfect state of preservation. The locality has furnished eighteen new species of crinoids and two of blastoids. These have all been described by Wachsmuth and Springer, and the descriptions and illustrations will be published in the forthcoming eighth volume of the Illinois geological reports.

THE AMERICAN NATURALIST, A MONTHLY JOURNAL devoted to Natural History and travel, and an old favorite with working naturalists everywhere, will be published during 1888

by the Leonard Scott Publication Co., of Philadelphia. Cope and Kingsley still hold the position of leading editors, and the department editors remain as last year.

THE "SCIENTIFIC" THIEF AND SWINDLER was detected lately at Franklin, Ind., by Prof. D. A. Owen, through the aid of the description published in the January GEOLOGIST. Prof. Owen confronted him in his private room with the description in his hand. He was not known to have stolen anything, but he left the town on the first express train. He was moving under the name of Otto L. Zyrski, as a deaf and mute Russian savant.

FRANK SPRINGER, now traveling in Europe, has recently procured a large lot of crinoids from the Carboniferous of England and the Eifel of Germany. The lot will afford valuable material for comparison with American forms, and will be so used in the preparation of the forthcoming monograph by Wachsmuth and Springer.

MR. CHARLES KEYES, A RECENT GRADUATE OF THE STATE UNIVERSITY OF IOWA, is doing splendid work in preparing the drawings for Wachsmuth and Springer's new monograph of the Palæocrinoidea. Mr. Keyes devoted much attention to geology and palæontology during his undergraduate course. His graduating thesis is an elaborate treatise on the geology and palæontology of Polk county, Iowa. It is a thick, royal octavo, manuscript volume, illustrated by a number of plates giving sections, profiles and numerous figures of fossils.

THE IOWA ASSOCIATION FOR SCIENTIFIC RESEARCH was organized on 27th December, 1887, at Des Moines. The officers of the Association are, president, Prof. Herbert Osborn, Ames; first vice-Pres. Prof. J. E. Todd, Tabor; second vice-Pres. Prof. T. H. McBride, Iowa City; secretary-treasurer, Prof. R. E. Call, Des Moines. The following papers were read by members:

By Prof. J. E. Todd, of Tabor College—1. "The origin of the extra-morainic till." 2. "Terraces of the Missouri." 3. "Decorative coloration in animals."

By Prof. B. D. Halstead, Iowa Agricultural College—4. "Artificial propagation of pollen of certain grapes."

By Prof. F. M. Witter, of Muscatine—5. "Shell hunting and shells in Decatur county, Iowa, and Lyon county, Kansas."

By Prof. Launcelot W. Andrews, State University—6. "On a new astatic galvanometer with a spiral needle." 7. "On the volumetric determination of lead, barium and sulphuric acid."

By Prof. H. W. Parker, of Grinnell College—8. "Animal intelligence."

By Prof. R. Ellsworth Call, of Des Moines—9. "Some forms of the Ozarks." 10. "Notes on the anatomy of Campeloma." 11. "On a new fossil from the Post-Pleiocene of California."

We wish the new association abundant success.

THE "WESTERN SOCIETY OF NATURALISTS" was organized at Indianapolis, December 29, 1887. This is an association of botanists, zoölogists and geologists, the objects of which are the discussion of methods of instruction and of research, as well as details of museum administration. The constitution adopted is essentially the same as that of the eastern "American Society of Naturalists." The officers for the following year are, president, Dr. S. A. Forbes of Champaign, Ill.; vice-presidents, Prof. W. J. Beal of Agricultural College, Mich., Pres. T. C. Chamberlin of Madison, Wis., and Prof. Henry L. Osborn of Hamline, Minn.; secretary, Dr. J. S. Kingsley of Bloomington, Ind.; and treasurer, Dr. John M. Coulter of Crawfordsville, Ind. It was voted to hold the annual meetings in October, the next one at Champaign, Ill. About forty naturalists have been enrolled as members.

PROFESSOR L. E. HICKS reports the occurrence of diatomaceous earth near the base of a bluff seventy-five feet in hight on the North Loup river in Nebraska. The bed is twenty feet in thickness; and while the diatoms are numerous, they make up after all only a small proportion of the whole mass.

PROFESSOR O. C. MARSH describes some interesting Mesozoic and Tertiary fossils in the January number of the *American Journal of Science.* For some time geologists have been puzzling over certain clays of undetermined age, outcropping between Baltimore and Washington. By direction of professor Marsh, Mr. J. B. Hatcher instituted a search in the clays for vertebrate fossils, and he was rewarded beyond all expectation by finding a rich fauna belonging to types characteristic of the Upper Jurassic. The forms brought to light by Mr. Hatcher and described by Marsh, consist almost wholly of the remains of Dinosaurs. The clays in question have been called by members of the United States geological survey, the Potomac formation. The formation evidently overlies the Triassic sandstones and seems to pass into clays which underlie the Cretaceous marls of New Jersey. It will be seen therefore, that the palæontological evidence and stratigraphical inferences are in harmony.

The Tertiary fossils described by Marsh in the same Journal consist of a series of teeth belonging to a peculiar Sirenian whose nearest living relatives are found among the dugongs,—belated creatures that seem very much out of place in our modern faunas. The teeth were found in California associated with a mastodon, camel, extinct horse and other species indicating the horizon of the Pliocene.

THE UNIVERSITY OF NEBRASKA is doing good work in geology and mineralogy. One of the recent accessions to the

geological laboratory is a complete machine for preparing rock specimens for the microscope; also a fine petrographical microscope with all the modern accessories.

Mr. G. B. Frankforter has chosen for his thesis for the Master's degree, "The Limestones of Nebraska." His skill as an analytical chemist, added to experience in the field, gives assurance of valuable results.

AND NOW COMES THE REPORT that diamonds have been found in meteorites. At least small granules, said to have all characteristics of the diamond, have been found in a meteoric stone that fell in Russia on Sep. 4, 1886.

MR. F. W. RUSSELL REPORTS A PEAT BED in the Loup country, in central Nebraska, six miles long, three miles wide, and from one to four feet thick. In some places it is deeply covered, but for the most part exposed and still forming. The peat rests on river sand and is hence siliceous at the base. It contains many diatoms, chiefly of the genus *Navicula*. It burns well, leaving no great amount of ash. In a region destitute of other fuel this deposit promises to be of economic importance.

PROF. L. E. HICKS LECTURED to the State Horticultural Society, of Nebraska, at its winter meeting on the "Relation of soils to geological structure," and to the State Agricultural Society on "Irrigation in Nebraska." He used for illustration an unpublished geological map of Nebraska, and a topographical map enlarged from Gannett, by C. G. McMillan, under the direction of Prof C. E. Bessey.

A VERY FINE COLLECTION of gold and silver ores has been presented to the University of Nebraska by Gen. Victor Vifquain, U. S. consul at Barranquilla, South America.

A STRATUM QUARTZYTE NEAR VALENTINE, Nebraska, contains free gold, but not in paying quantities.

A bed of black marl, with numerous shells of fresh water mollusca, in the valley of Pumpkin creek, Cheyenne county, Nebraska, will sometime prove useful as a fertilizer.

A fine kaolin-like clay from Pine creek, in Cherry county, has been received from Rev. G. W. Reed. The clays of Nebraaska are excellent, and will form the basis of important industries, at no distant day.

DR. METZ, OF MADISONVILLE, NEAR CINCINNATI, is reported to have recently found two palæoliths in undisturbed glacial ground at that place. This, if confirmed, will be another argument for the great antiquity of man on this continent, and will be in line with the discoveries of Dr. Charles C. Abbott, in New Jersey, and of Miss Babbitt, in Minnesota..

All these, if they should ultimately prove genuine, will also

confirm the work of Dr. Hicks, in England, who has recently published the details of the exploration of a cave which he maintains is of preglacial age, and the evidence for the claim seems unusually good.

In all these cases, however, the word "preglacial" is rather loosely employed, and should be held to mean possibly "interglacial." The fact that these relics were found beneath undisturbed glacial deposits does not prove preglacial age, but only that the objects are not postglacial. Unless the proof is clear that these beds belong to the earlier portion of the ice-age, they should not be called preglacial. There is apparently good evidence that there have been two distinct advances of the ice, and the term "preglacial" ought to be kept strictly for use in reference to events that preceded the earlier of the two.

We have as yet no evidence at all of preglacial man on Earth, but the evidence for the existence of interglacial man is yearly becoming stronger, and at the present rate will soon be conclusive. But it must be borne in mind that the earlier the date at which we seek to establish man's existence, the stronger must be the evidence that is adduced in support of the claim.

AT THE LAST ANNUAL MEETING of the Indiana Academy of Sciences, held at Indianapolis, Dec. 28th and 29th, the following geological papers were read:

The east-west diameter of the Silurian island about Cincinnati. D. W. Dennis.
Erosion in Indiana. J. T. Scovell.
A geological section of Johnson county, Indiana. D. A. Owen.
Notes on some fossil bones found in Indiana. O. P. Hay.

The officers for 1888 are J. P. D. John, president; John C. Brunner, T. C. Mendenhall, and O. P. Hay, vice-presidents; Amos W. Butler, secretary; O. P. Jenkins, treasurer.

ACCORDING TO PROF. CHAS. W. ROLFE, of Urbana, Ill., the gas wells at Litchfield in that state, which are the only high-pressure wells which have been obtained in Illinois, and which a year ago were supplying 800 stoves, have so diminished in pressure that they now furnish but eighty. The supply of lubricating oil in that vicinity does not seem to have sensibly diminished.

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SOME EFFECT OF PRESSURE OF A CONTINENTAL GLACIER.[1]

BY ALEXANDER WINCHELL.

The terrestrial globe in some of its behavior, may be compared to an India rubber ball filled with water. If indented by pressure in one place, there must be a protuberance equal in volume in another place. In a ball of uniform composition, the protuberance would be spread over the entire surface beyond the region indented, and the effect in one particular spot might be insignificant. Should a small area of the caoutchouc be thinner than the rest, that part would be protruded to a greater extent than other parts of the surface. Should there be small holes or fissures through it, the water would escape and flow over the surface. That is, the protuberance resulting from local pressure would be chiefly on the outside of the shell. As we ordinarily conceive it the water would be squeezed out —like the juice of a squeezed orange.

The analogy of the earth does not depend on the theory of a molten interior beneath a solid crust. Whatever weight or force is adquate to indent the world's exterior develops, by crushing mechanical action, heat enough to fuse the rocks and supply liquid material. The amount supplied is proportioned to the magnitude of the action. It is generally admitted that ocean sediments accumulated on a large scale, have in many cases, produced a subsidence of the bottom on which they rest. In some cases, we can point out the regions elevated as the counterpart to the subsidence. I think in some cases, we may

[1] The views here enunciated were published in the University *Argonaut* in March, 1886.

point out escapes of molten lava as sequences to sedimental pressure; but geologists have not done this in any articulate way; and the principle involved is one of the points at which I aim in this memorandum.

One of the great doctrines of geological science which have found their way into common knowledge and acceptance, is the doctrine of former general glaciation of the north temperate lands. North America, east of the Rocky Mountains, and as far south as Cincinnati, was covered by a sheet of glacier ice, which perhaps averaged a mile in thickness. Its pressure upon the earth's exterior will readily be understood as enormous, and the reader can easily reach a numerical result. It will be borne in mind that the whole weight of the ice assumed the form of a pressure; while in the case of ocean-sediments, whose effects are generally admitted, the buoyant action of the sea-water prevents about half the weight of the sediments from assuming the form of a pressure in excess of that already exerted by the water.

Now where was the region subjected to protrusion in response to the enormous pressure of the great ice-mass? The view which I wish to enunciate is, that some of the region west of the Rocky mountains was the theatre of actions responsive to the great eastern and northern pressure. It is established that those regions were not generally glaciated. They must consequently, have experienced a tendency to become protuberant. Some regions may have been bodily uplifted. If fractures were thus caused, an escape of molten matter may have permitted such regions to subside. There are evidences of simple vertical actions and movements such as would thus result. If, however, fissures existed, or were produced, through which outflows of lava could take plaee, then instead of a vertical elevation of the crust, a flood of lava would cover the country.

Such floods of lava have occurred. Vast sheets of frozen lava are the most conspicuous feature of a region embracing large parts of Washington, Oregon, Idaho, Nevada, California, Arizona and New Mexico. In Oregon and Washington there was an almost universal flood of molton material, which covered and buried the whole original face of the country—hills and dales, mountains and valleys. Its extent is estimated by Le

Conte at not less than 150,000 square miles, with a thickness of three to four thousand feet. The Columbia river at the Cascade Range, has cut through 2,500 to 3,800 feet of lava.

Heretofore the epoch of the outflows has been placed late in the Pliocene—*before* the Glacial epoch. On this assumption, American man has been located in the Pliocene, since his remains have been found in California beneath the great sheet of lava which caps the celebrated Table mountain of Calaveras county. The relation here suggested, but hitherto overlooked between western lava outflows and eastern ice-pressure has therefore, the ulterior effect of reducing the supposed antiquity of man in America, and thus of harmonizing his chronology with that of European man.

This conclusion is indicated on other grounds. Remains of man have been found associated with *Equus occidentalis* and *E. excelsus* Leidy, in Oregon, in beds held by Cope and Marsh, it is true, to be Pliocene; and a similar association is reported from Colorado by Dr. Gilbert. The account of these observations has not yet been published; but from personal information from Dr. Gilbert, I learn that he and Mr. Mc Gee connect the Equus fauna of Oregon with the Glacial epoch rather than the Pliocene; and this result is in accord with what I anticipated on theory, may be found to be the truth in California, in respect to the gravel beds holding human remains underneath tables of lava.

This method of viewing the subject of continental glaciation leads to another suggestion. If the terrestrial crust, to the east of the Rocky mountains and north of the Ohio river, was deeply indented by the weight of a sheet of ice say five thousand feet thick; a change must have resulted in relative levels of land and sea in the regions contiguous to the ice-boundary. The crustal depression would not be limited strictly to the ice-covered area. The crust's partial rigidity would cause the depression to be experienced along a bordering belt many miles in width. That is, the original Atlantic border of Labrador and New England would be depressed, and so would a belt through New Jersey, Maryland, Kentucky and Illinois lying along the southern limits of the glacier.

Along shores reached by the glacier, the ocean would bathe

the glacier and dissolve it more or less rapidly. On coasts where the glacier's motion was inconsiderable, the action of the sea maintained a bare shore line; and beach history was recorded as if the interior had not been ice-covered. The most important records would consist of beaches. The gulf of St. Lawrence, along the south shore, would have been kept free from ice, and a succession of beaches would record the successive stages of sea-level. Thus genereally, on shores trending meridionally, and more especially on southern shores, a series of beaches would be formed, while probably northern shores, through the constant encroachment of the glacier, might be kept completely concealed. The beaches formed during the progressive relative rise of the water would probably be obliterated, but, as usual, the beaches formed during the receding phase, would remain as records and evidences of the former submergence.

The theory implies that the greatest crustal depression would be experienced northward; the depression would gradually diminish southward. That is, the beaches northward would attain the highest elevations in relation to the preglacial level of the land. On the final dissolution of the continental glacier, and the restoration of the land to its former level, these beach-records would be found attaining progressively higher levels toward the north. The theory implies also that elevated beaches would be formed along all shores bordering glaciated lands—whether American, European or Asiatic.

Now witness the facts. Inland beaches whose geological relations connect them with the last great events of the world's history are actually found along the Atlantic coast from New York to Labrador, and even to arctic latitudes. On the southern coast of New England ancient beaches are found from ten to twenty-five feet above present sea-level; on Nantucket, 85 feet; on the coast of Maine, 27 feet; on the borders of lake Champlain,—then a part of the gulf of St. Lawrence—350 feet; at Montreal, 500 feet; on the Labrador coast, 500 to 800 feet; on the arctic shores, 1000 feet. Commander De Long found elevated beaches on Bennett island, at the altitude of——feet.

This theory further implies that the formation of the beaches was *synchronous* with the prevalence of wide glaciation. The

common opinion has been that the subsidence followed glaciation, and was a phenomenon of the Champlain epoch rather than the glaciation. Under the views here set forth the beaches which remain date from the commencement of the decline of the glacier.

Croll, who has so ably speculated on the causes of continental glaciation, conceived the icy load as heaped above the former level of the continent.. He viewed the crust as too rigid to bé depressed by the weight. A polar ice-protuberance of 5,000 feet, and covering all the north temperate lands, would shift the earth's centre of gravity northward to a certain extent. The oceans would as a consequence, flow northward to restore the proper figure of the earth, and all northern lands would suffer inundation. This reasoning becomes nugatory in the face of much evidence that the earth's crust has many times yielded to the pressure of accumulated sea-sediments, and would much more yield to the weight of a continental glacier.

THE RIVER-LAKE SYSTEM OF WESTERN MICHIGAN.

BY C. W. WOOLDRIDGE, B. S., M. D.

The attention of geologists does not seem to have been directed to the pecūliar system of river-lakes found along the eastern border of lake Michigan, to the degree which their importance merits.[1]

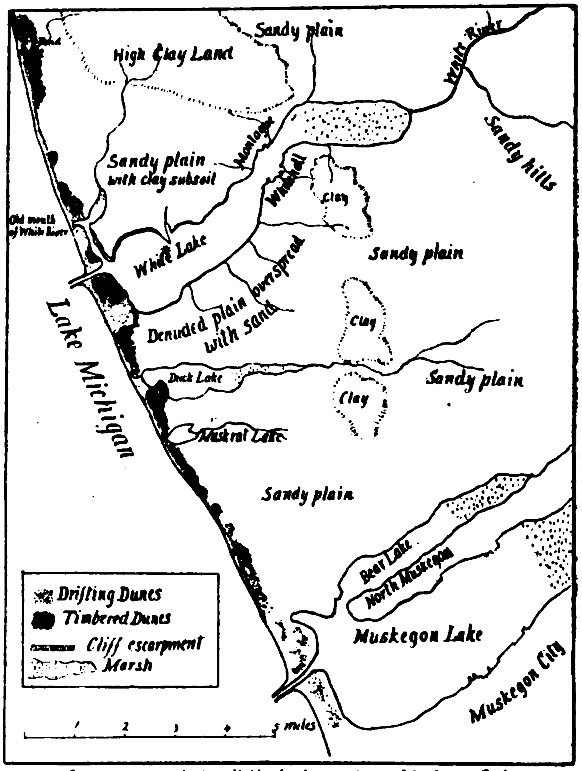
The map accompanying this article represents a portion of the lake Michigan border, along the northern part of Muskegon county, Mich. A glance at any good map of the state will show that the system of lakes occupying the lower valleys of streams flowing into lake Michigan, which the region depicted in this sketch so well illustrates, continues throughout the whole length of the east shore of lake Michigan, from Grand Traverse bay on the north to the St. Joseph river on the south.

A careful study of the vicinity of White lake, shown in the

[1] These features were pointed out and mapped by Alexander Winchel in an article in Harper's Magazine for July, 1871, p. 284. [Ed.]

accompanying map, together with more cursory observations at various points from Grand Traverse bay to the mouth of the Grand river at Grand Haven, enables me to state the following facts regarding this system of lakes and the region where they are found.

1st. These lakes assume the same form that would be produced if they were covered by dams across the river valleys at



In order to include all the features shown, Muskegon Lake and its vicinity are placed about one mile too far north on this map.

there outlets. They are elongated in the same general direction as the valleys of the streams which flow into them. They are deepest toward lake Michigan, they terminate, or begin, in marshes at their inland extremity, and they usually extend some distance into the valleys of tributary streams flowing into them.

2nd. Their beds are excavated in the drift clay, and not in

surface sand which over spreads the lower levels in their vicinity. The region bordering White lake on all sides is composed of clay, over spread with a stratum of sand varying, usually, from one foot to four feet in depth, though in places it is deeper. The clay surface reaches a hight of 15 to 30 feet above the level of the lakes, and a portion of the strip of land which separates it from lake Michigan, even, consists of a hill of drift material, mostly clay, partly covered with a timbered dune.

I have also made observations which go to show a similar structure in the case of other lakes of this class, especially Duck lake, shown on the map, Pentwater lake, and Manistee lake. All these lakes seem to be submerged portions of the river-valleys in which they lie, and such I believe they are in fact.

3rd. The present bottoms of these lakes are the product of sedimentation and not of erosion, and that to such an extent as to obliterate any features due to erosion which may originally have existed in them. Of this fact I have convinced myself by sounding through the ice on White lake and Duck lake, though I had anticipated a contrary result.

4th. The original slope of the bottoms of these lakes in the direction of drainage must have been much greater than of the country farther inland. I have myself sounded a depth of 84 feet in White lake at the point indicated thus* on the accommpanying map. It is about seven miles from this point to the head of the marsh where the original lake bottom coincides with the present water level, from which it appears that a fall of least 84 feet existed in the original river bed between these points. From the head of the marsh up stream it is necessary to go at least twenty miles in order to find an equal change of level.

5th. The valleys occupied by these lakes appear to have extended across the present border line of lake Michigan into deep water. At the foot of such river-lakes as these, in every instance known to the writer drifting sand-dunes now exist. At some time not very remote a much more extensive system of drifting dunes existed in this region than is now found, but long reaches of these dunes have become timbered and fixed. In such places the dunes are separated from the present beach sand by an escarpment cut in the clay that underlies them. This clay is what remains of the denuded surface of the older

country upon which the present surface sands-dunes and plains, have been deposited. Where that surface lies higher than the present level of lake Michigan, that lake has cut into it and the bank thus formed has separated the dunes formerly de-deposited on this clay from the beach sand which the waves are constantly shifting. In some places the old chain of dunes seems to have been entirely cut away; in others, they remain fixed and timbered as described. Where the clay surface does not rise to the present level of the lake, the beach sand formed an uninterrupted slope up the dune, and in such places the sand continues to drift, while the waves on the beach continue to furnish a new supply.

When examined, the presence of such drifting dunes will probably be found in every instance, to coincide with a depression of the clay surface underlying the west Michigan sands below the present level of the great lake.

6th. This clay surface, wherever overspread by sand, a condition co-extensive with the lower levels of the country to a hight estimated at 75 feet above the lake, bears the marks of denudation by waves, and has evidently been submerged beneath the waters of the great lake. Above that level the character of the land is that usually found in drift-clay regions. The surface is not generally overspread with sand, the denudation which has taken place upon it seems to be the effect of weathering, and the eastern borders, especially, of such elevated tracts are plainly traceable along a continuous level, showing them to have been islands at the time when the surrounding plain was submerged and denuded.

ON A NEW POST-PLEIOCENE LIMNÆID.

BY PROFESSOR R. ELLSWORTH CALL.

Des Moines, Iowa, 28th November, 1887.

In 1883, while the writer was engaged in the preparation of a report on the mollusca of the Great Basin, Dr. R. E. C. Stearns kindly submitted for study certain specimens of a fossil shell supposed to belong to *Pompholyx*. The specimens had been collected by the California geological survey and were

placed in the cabinet of the state university, at Berkeley, where they may now be seen.

At the time the shells were received a careful study was made of them, and figures drawn of the largest and best preserved specimen. They were recognized as not belonging to *Pompholyx*. Reference to them was not made in the report cited for the reason that they were extra-limital. It is now proposed to describe these specimens as the type of a sub-genus, not hitherto recognized, its sole species being dedicated to Dr. Charles A. White, of Washington, the veteran palæontologist.

POMPHOLOPSIS[1] WHITEI, *subg. et sp. nov.*

Figs. 1-3.

1 2 3

Shell dextral, globose, rather solid, deeply umblicated; whorls 3—3½, convex, body whorl very large; spire short, apex obtuse; aperture roundly ovate; peritreme continuous, forming a heavy callous on the parietal wall of the body-whorl. Growth lines inconspicuous, surface of the shell smooth; sutures rather irregularly impressed.

Length 7.26 *mm.*; diameter 8.13 *mm.* This is the size of the largest of four or five specimens. Post-Pleiocene, Tassajara Hills, California. Prof. Gabb.

The resemblance between this form and *Pompholyx effusa* is marked, but not less so are the differences. It is an umblicated shell, is heavier and larger, and comes from strata older than any in which *Pompholyx* has yet been recognized. The apertural characters are decidedly different, not at all effuse, and very regularly rounded ovate. Generic and specific characters are necessarily combined, but the umbilicus will distinguish it at once from any other similar Limnæid.

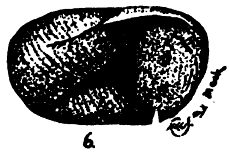
There are now two fossil and two recent, (if *Ameria* be excepted) subgenera of limnæid mollusca which resemble each other in important particulars—perhaps sufficiently to give the whole number rank as a subfamily. To facilitate comparison

[1] Etymology —*Pompholyx*, a sub-genus of mollusca, *opsis*, aspect of.

of these forms copies of the figures are given below — figs. 4, 5 and 6; and the following table of generic characters.

4.

5.



6.

CARINIFEX (1863)[1]	POMPHOLYX (1856)	VORTICIFEX (1870)[4]	POMPHOLOPSIS (1887)
Shell dextral, spiral, inflated, angular, horn-colored, spire terraced, whorls numerous, angular, visible above, last whorl very large, broad above, very rapidly attenuated below; umbbilicus funnel-shaped; aperture triangular, broad above, narrow below; inner lip slightly thickened; outer lip thin, acute, angular above, flexuose.	Shell dextral, depressed, globose, translucent, horn-colored; spire short, obtuse, last whorl very wide, ventricose; aperture very large, wide, subcircular, expanded; inner lip thickened, outer lip acute.	Shell dextral, depressed sub-globose, umbilicated; volutions rapidly increasing in size, last one equaling nine-tenths bulk of shell, produced below so as to form a prominent ridge around the widely excavated umbilical region; aperture large, subovate, widest above, subangular below; lip oblique; lines of growth oblique, sometimes forming little regular costæ.	Shell dextral, globose, rather thick, deeply umbilicated; body whorl very large; spire very short, 2-2½ whorls; aperture roundly ovate, peritreme continuous, outer lip acute.
Figure 5.	Figure 4.	Figure 6.	Figures 1–3.
Species two.[2]	Species two.[3]	Species two.	Species one.
Recent.	*Recent.*	*Fossil.*	*Fossil.*

[1] Proposed by Mr. W. G. Binney, Dec. 9, 1863, but not described. *Megasystropha*, proposed by Mr. Lea (Proc. Phila. Acad. Jan., 1864, but not described.) *Carinifex*, described by Binney, Am. Jour. Couch., vol. i, p. 50, 1865.

[2] One of these two *described* species, namely *C. ponsonbyi* E. A. Smith, may prove to be a local variety of *C. newberryi* Lea, the type of the genus. In connection with this name a curious interchange of figures and descriptions occurs — noticed by Mr. Smith but uncorreeted in print so far as I know. *C. ponsonbyi* was described in Proc. Zool. Soc. London, 2 Nov., 1875, pp. 536 538. The *figure* illustrating it is *Diala leithii* E. A. Smith. This last named form is described at the same time, also from California, on pp. 539-540, but the *figure* there given is the *C. ponsonbyi* E. A. Smith. *C. breweri* Newcomb, has never been described.

[3] One of these described species, *P. solida* Dall, is possibly not sufficiently distinct from the typical form to take rank as a species — nor indeed as a well-marked variety.

[4] The type of this genus — *Vorticifex binneyi* — was described by Mr. Meek under the name of *Carinifex binneyi*, *Vide* Proc. Phila. Acad. Sci.,

NOTES ON THE FOSSILS OF THE LOESS AT IOWA CITY, IOWA.

BY PROFESSOR B. SHIMEK.

The typical Loess deposits of the vicinity of Iowa City contain an abundance of specimens of mollusk remains, the careful study of which will no doubt cast much new light on the evolution of some modern species, as well as on the climatic conditions under which these forms existed.

In the following brief notes I will merely make a comparison of our Loess fossils with the same species now living here, as I desire to reserve the results of more extended observations for a future paper.

All of the species noted in the following list were collected by myself in the immediate vicinity of Iowa City, and the greatest care was exercised to admit no old, bleached recent shells as Loess fossils. The rarer species were all obtained by digging in hitherto undisturbed Loess.

1. *Zonites arboreus* (Say.) Binn. Only three imperfect specimens very much like our recent forms were found.

2. *Zonites viridulus* (Menke.) Binn. Two fine specimens were taken which were rather smaller than average recent ones.

3. *Zonites minusculus* (Binn.) Fisch. and Cr. Three fossil specimens were found. My largest recent specimen measures 2½ mm. in greater diameter, whereas the three fossils measure each three mm.

4. *Zonites limatulus* (Ward.) Binn. The fossil forms are of frequent occurrence. The species does not live here at present, but our fossils are much larger than any recent specimens which have come to my notice.

5. *Zonites fulvus* (Drap.) Binn. Abundant. Average greater

1870, p. 59. But in a foot-note on same page he writes, "I propose the subgeneric name *Vortifex* for these shells, which differ from the typical forms of *Carinifex*." Attention was elsewhere called to the orthography of the subgeneric name, which should have been *Vorticifex*. No diagnosis of the subgenus was ever given, and the one herein offered is based on Meek's specific description of *V. Binneyi*, which he has designated as the typical species.

diameter 3½ mm. This is somewhat greater than in our recent forms.

6. *Patula strigosa* (Gould.) Binn. The variety known as *P. cooperi* occurs in one of our exposures. The species is extinct in this locality.

7. *Patula striatella* (Anth.) Morse. This is one of the most common species of the Loess. The average measurement of the fossils is about equal to that of the recent specimens. The fossil eggs of this species are frequently found.

8. *Helicodiscus lineatus* (Say.) Morse. But four specimens were found, which do not differ from the average recent forms.

9. *Ferussacia subcylindrica* (L.) Binn. Five fossils were found which are in all respects like the only two recent specimens which were collected here.

10. *Pupa armifera* Say. But few specimens occur, and these are scarcely distinguishable from recent specimens, except by the unmistakable bleached character so peculiar to Loess fossils.

11. *Pupa muscorum* L. Rather common. Now extinct in this locality.

12. *Pupa blandi* (Morse) Binn. Many hundred specimens were taken. The recent form is not found here.

13. *Vertigo simplex* (Gould) Stimp. Several hundred specimens which have been referred rather doubtfully to this species, were taken. The species is now extinct in this locality, but the dimensions of recent types are given as: length, $1\frac{3}{5}$ mm., diam., $\frac{4}{5}$ mm., and the number of whorls as five; whereas the best specimens of our fossil form measure 3¼ mm. in length and ⅞ mm. in diameter, and the number of whorls is *seven*. In all respects, excepting length and number of whorls, our specimens are certainly *V. simplex*, though a number of conchologists have returned them to me as *Pupa muscorum* L.! *P. muscorum* has twice the diameter of this *Vertigo*, and its aperture with the slightly expanded lip differs very much from that of the *Vertigo*, which is regularly rounded, with a simple lip.

14. *Mesodon multilineata* (Say) Try. The fossils are of frequent occurence, but they are much smaller than our recent specimens. The smallest fossil specimen which was found measures 12½ mm. in greater diameter, and the largest 16 mm.,

whereas recent specimens from this locality vary from 22 mm. to 26 mm. I have, however, collected recent specimens in Hardin county, the smallest of which equals the largest fossils, *i. e.* 16 mm. in greater diameter.

15. *Vallonia pulchella* (Muell) Binn. The fossils are quite abundant. Their average greater diameter is three mm. The recent forms average only two and a half mm.

16. *Succinea avara* Say. The form which has been referred to this species occurs in great abundance in our Loess. It certainly is not typical *S. avara*, but coincides more nearly with Binney's description and figure of *S. verilli* Bland, a boreal species. Our specimens average a trifle more than seven mm. in length. Our low-land form of living *S. avara* is very much larger and has a proportionally larger body-whorl, while the form which lives in dry rocky places is more corpulent. Both are unlike the fossil form.

17. *Succinea vermeta* Say. A form identical with the large *S. avara* known commonly as *var. vermeta* occurs in great abundance in our deposits. It seems to change however so gradually into the narrow, depauperate forms of *S. obliqua* that in a set of several hundred specimens I find it impossible to satisfactorily separate the two forms. Many of the fossil specimens are identical in form and size with the recent ones, but the average is rather larger.

18. *Succinea obliqua* Say. The fossils referable to this species are somewhat smaller, narrower and have a more elevated spire than our local recent specimens.

19. *Limnæa caperata* Say. Common. The fossils are smaller than our recent local form, but are equal to specimens from Marshall county, Iowa.

20. *Limnæa humilis* Say. Two forms of this variable species occur locally in considerable abundance. The broader form with longer aperture and shorter spire finds its exact counterpart in our local living form, but the other does not occur here now.

The latter form has been erroneously called *L. desidiosa.* It may prove to be distinct.

21. *Limnæa desidiosa* Say. Specimens which may be referred to this species are occasionally found. They are much smaller than the recent local form.

22. *Leptolimnæa* ——. One perfect specimen of a *Leptolimnæa* unlike any local living species was found.

23. *Physa* ——. One young specimen was found. The species could not be determined.

24. *Helicina occulta* Say. Abundant. The fossils average smaller than the several thousand recent specimens taken near Iowa City, but are nearly equal to the specimens from Eldora, Iowa.

25. *Pisidium* ——. Two perfect valves and several fragments of others were found. The species could not be satisfactorily determined.

It will be observed that with the exception of *Helicina occulta* Say and *Pisidium* —— all of these mollusks are *Pulmonates*. Of this list numbers 4, 6, 11, 12, 13, and 22 are now extinct in this locality. Numbers 1, 7, 8, 9, 10, and 20 (the first form) have remained unchanged. Numbers 2, 14, 16, 18, 19, 21, and 24 are now better developed than formerly, and numbers 3, 5, 15, and 17 have degenerated. Numbers 14, 19, and 24, are placed in the list of forms which, in this locality are better developed than formerly, but specimens from other parts of the state approach our fossils very closely. The probable causes of these variations will be discussed in the future.

DARWIN AND GEOLOGY.

BY PROF. E. W. CLAYPOLE.

The publication of the *Life of Charles Darwin* by his son has afforded a suitable opportunity to review the labors of this greatest of recent naturalists. Charles Darwin was not a biologist on the model of those who limit the field of biology to the study of structure with the aid of the microscope and the microtome. Invaluable as are these engines of research they had little or no place in his laboratory. But in the wide field of observation and experiment, not with the dead but with the living organism, he was a biologist of the first rank. With this department of his work, however, we have little direct concern. But a man of the first rank in one department of nature is almost sure to cross the limit and enter on the ground of other

departments. His greatness is often shown by the extent and the direction of his footprints. A master workman in one art will often show his masterhood when he touches another. Agassiz was a naturalist, but to him geology is indebted for the "glacial theory." Leonardo da Vinci was a painter, but geology in her early days, not to mention other sciences, was not a little aided by him. Huxley is a biologist, strictly speaking, but palæontology, and, we might add theology, have both reaped advantage from his labors. Of such men it has been said and may be said again,

"Nihil fuit quod non tetigit, nihil tetigit quod non ornavit."

In like manner the great master who has so recently passed away, though a biologist so far his great discovery was concerned, was a naturalist in the widest sense of the term, and if biology has reaped the greatest results from his labors yet geology has picked up the crumbs that fell from that richly laden table, and these crumbs have been of no slight value.

We propose therefore to devote a few pages to a review of the important step which geology has made during the lifetime of this remarkable man. Such a sketch will include the work of other men more or less closely connected with him. It may be of interest to many of the younger geologists of the present day to look through the eyes of their elders and view the progress of their science during the past sixty or seventy years. To us all it may not be unprofitable to see that "Other men labored and" we "have entered into their labors."

For our purpose it will not be necessary to dwell on the details of Darwin's long and busy life. At the age of sixteen he went to the University of Edinburgh. This was in 1825. At the beginning of the present century the geological world had just passed through one of the most violent and bitter of the controversies that have marked its by no means peaceful history. The conflict between the two schools, the Vulcanists and the Neptunists, was then at its hight. The eloquent Werner, professor of mineralogy at Freyberg, in Saxony, had adopted the view, derived from the study of the rocks near that town, that all the strata composing the crust of the earth had been formed under water. He freely introduced *catastrophe* to ex-

plain or remove difficulties in his system. The genius of the man threw a halo around the theory that he propounded, and contributed in no small degree to give currency to views that in themselves were untrue because based on a too narrow induction.

Hutton, on the other hand, the great apostle of the Plutonists, was maintaining at Edinburgh, that many of the rocks composing the crust of the earth had been poured forth in a molten state from the interior. In support of this opinion he appealed to facts that could not be gainsaid, such as dikes and veins of granite, &c. As Werner may be classed among catastrophic geologists, so Hutton may be called a uniformitarian. He advocated the view that the present state of things was the outcome of a former one and that the facts of geology require for their explanation a vast series of years. "I can find," said he, "no traces of a beginning, no prospect of an end." The teachings of Hutton were the first to bring distinctly before geologists this now fundamental article of their faith — the immense length of geologic time. Many recoiled, appalled at the spectre that was slowly taking shape before them. The new doctrine served as a touchstone to sever the courageous and unflinching followers of reasou from the crowd that could not or would not see the force of the evidence. The disciples of Hutton were few; those of Werner were many. Neptunism was fashionable. Above all, the aqueous doctrine was orthodox while the igneous doctrine was heterodox. With the multitude this determined the choice.

We are ready to laugh in these days at the wide prevalence of a doctrine that had absolutely no foundation save the eloquence of its founder, but a little thought will show us that the same state of things has occurred many times over in the history of science. It was, however, no laughable matter in those days. So high did the feeling run that Lyell in writing on the subject says, "The heretical Vulcanists were soon after assailed in England by imputations of the most illiberal kind. It was perhaps better for a man's good reception in society that his moral character should have been traduced than that he should become a mark for these poisoned weapons — charges of infidelity and atheism."[1]

[1] Principles, p. 55, 1853.

The echoes of this acrimonious controversy had not died away when Darwin went to Edinburgh. But a temporary calm was then prevailing, due to the suppression of the heretical Vulcanists by the strong arm of public opinion. Their total and final suppression was, however, impossible because truth was on their side. The result was of course to take the life out of geological teaching and interest out of geological study. No power can permanently galvanize into the semblance of life that which is surely and finally dead. Without therefore attributing to young Darwin any other virtue in this respect (which he did not apparently possess) than the power of seeing when the evidence supported the teaching, we are not surprised to read (p. 36):

"I attended ——'s lectures on geology, but they were incredibly dull. The sole effect they produced on me was the determination never, so long as I lived, to read a book on geology, or in any way to study the science. Yet I feel sure that I was prepared for a philosophical treatment of the subject." What kind of teaching he "enjoyed" may be gathered from the following sentence: "It is the fact that I, though now only sixty-seven years old, heard the professor in a field lecture at Salisbury Craigs, discoursing on a trap rock with amygdaloidal margins and the strata indurated on each side, and with volcanic rocks all around us, say that it was a fissure filled from above, adding with a sneer, that there were men who maintained that it had been injected from beneath in a molten condition. When I think of this lecture I do not wonder that I determined never again to attend to geology."

The biographer has judiciously concealed the name of the professor, but those who are familiar with Edinburgh of that day will find no difficulty in filling the blank if they recall a well known teacher of a theory even then well nigh antiquated.

Times have changed, and now from the same chair are heard the once denounced doctrines of Hutton and Playfair, while the peculiar tenet of Werner has sunk into well deserved oblivion.

The dislike to geology aroused at Edinburgh prevented, so he says, his attending the eloquent and interesting lectures of Sedgwick at Cambridge. But he was strongly attracted by

the varied learning and genial disposition of the professor of Botany, and became a constant attendant and later a companion of Henslow, whose influence was great and lasting. To this accomplished teacher and good man biology is largely indebted for enticing into the paths of science his equally good and more gifted pupil. His wisdom and kindness undid the mischief that the bigoted Edinburgh professor had done, and won over again to geology the mind that had been estranged. Darwin never became a geologist, but in the hands of Henslow he soon lost all dislike of the science; it received a due share of his attention and has reaped a large harvest from his labors.

He was not long in making the acquaintance of Sedgwick, and accompanied him in some of his geological excursions. Of one of these an account is given in the memoir, and from it we gain another glimpse no less striking of the state of our science in 1830, or about sixty years ago.

"Next morning we started for Llangollen, Conway, Bangor and Capel Curig," all situated around the central peak of Snowdon. "Here," he says, "I had a striking instance of how easy it is to overlook phenomena, however conspicuous, before they have been observed by any one. We spent many hours in Gwm Idwal, examining all the rocks with extreme care, as Sedgwick was anxious to find fossils in them, but neither of us saw a trace of the wonderful phenomena all around us. We did not notice the plainly scored rocks, the perched boulders, the lateral and terminal moraines. Yet these phenomena are so conspicuous that, as I declared in a paper published many years later in the "Philosophical Magazine," a house burnt down by fire did not tell its story more plainly than this valley." It seems almost incredible, familiar as we are with the *Glacial Theory* of Agassiz, that the professor of geology at Cambridge could be so absorbed in the search for fossils as to pass through the central domain of south British icedom and see nothing and ask himself nothing of the marvellous ice sculpture that covers the rocks around Snowdon. But so it was. Sedgwick went through a region where almost every stone and rock was covered with inscriptions cut by the ice-chisel, but they failed to excite his curiosity or to attract his attention. Agassiz had not yet found the Rosetta stone.

The following remarks of Darwin on Carlyle in this connection are amusing, keen, and most will admit true. "It is astonishing to me that Kingsley should have spoken of him as a man well fitted to advance science. He laughed to scorn the idea that a mathematician, such as Whewell, could judge, as I maintained he could, of Göthe's views on light. He thought it a most ridiculous thing that any one should care whether a glacier moved a little quicker or slower, or moved at all. As far as I can judge I never met a man with a mind so ill adapted for scientific research."—p. 64.

There has come in the life probably of every great man a turning-point, marked by some perhaps insignificant circumstance, which was the means of directing his thought and energy into the channel in which they afterward remained. So it was with Darwin. It was in the year 1831 when he was twenty-two years of age that two events occurred almost simultaneously that tended to confirm him in his devotion to science, and at the same time to attract him very powerfully to biology, and geology. These were, his appointment as naturalist on the "Beagle" during her voyage of discovery, and the publication of Lyell's "Principles of Geology," a copy of which he bought at the suggestion of his friend Henslow, who however cautioned him "on no account to adopt the views therein advocated."

To realize the significance of these words we must recall the state of geology in 1831. The theological fetters which at Edinburgh had obstructed the sagacious Hutton and his disciples in the promotion of his doctrine of the igneous origin of certain rocks, and the great length of geological time, were equal obstacles in the path of Lyell and his then new school of Uniformitarians. The advisability, in the minds of the old or conservative school of geologists (if indeed they deserved the name,) the absolute necessity, in the opinion of theologians, and unreasoning prejudice on the part of the multitude who caught up their ideas at second-hand but for that reason clung to them all the more doggedly—all these combined to suppress independent thought along certain suspected lines, and to foster attempts to close or to bridge the chasm that was beginning to yawn between the two parties. Apprehension on both sides produced opposite results. The geologists of the new school kept silence

while their opponents took and held possession of the public ear. It is amusing and at the same time instructive now to read the works that were then issued—many of them in perfect honesty but some we fear by mere special pleaders—to show that there is no inconsistency between the narrative in the Hebrew Scripture, literally interpreted, and the story of the rocks. The bed of Procrustes was a trifle compared with the extraordinary torture which was applied to both in order to bring them into accord. The treatment of the geologic record involved, often through ignorance, the suppression of the most awkard difficulties and the most obvious facts, so that the version gave but a garbled report of the story of the rocks; while on the other side we are reminded of the acute remark of professor Huxley that a "layman can only stand aside and marvel at the wondrous flexibility of a language which admits of so different and even opposite interpretations."

To this class of books belong Granville Penn's *Comparative Estimate of the Mineral and Mosaical Geologies*, Pye Smith's *Scripture and Geology*, and last, though by no means least, *The Testimony of the Rocks*, which may truly be said to have been purchased with the life of Scotland's great geologist, Hugh Miller. To these we refer such of our readers as desire more detail concerning the state of the geological world on this point during the past half century.

Such a condition of thought naturally associated orthodoxy with one school and heterodoxy with the other. Those who essayed to maintain against heavy odds the literal accuracy of the Mosaic poem of creation, direct and special, formed the party of the *Catastrophists*, and were in the majority. Their opponents, few in number and weak in position, who supported the view that the present fauna and flora of the earth are, in some as yet not fully explained way, the direct and lineal descendants of others previously existing through a vast lapse of time, were later known as *Uniformitarians*. The leading scientific apostle of the former was the French geologist, Elie de Beaumont. From an examination of the mountain-systems of the earth this distinguished savant had deduced the theory that all parallel ranges were coëval. By a refinement on his theory, which the data were quite incapable of justifying, he

announced the occurrence of twenty-nine separate catastrophes, each produced and immortalized by one or more mountain-systems. To each of these he gave a name derived from the ridge that best exemplified its direction. Thus he enumerated the *System of the Longmynd*, of the *Pyrenees*, of the *Western Alps*, &c. All these were laid down on his maps and their relative dates determined. E. de Beaumont further maintained that each of these mountain-systems had been violently and suddenly upheaved with great commotion, and that each upheaval had been accompanied with catastrophe so wide-spread and disastrous as to utterly destroy all living beings on the face of the globe. As a writer of the time has expressed it,

> In the interval following each such deluge creative power was again brought into operation and the earth was repeopled with animated creatures and reclothed with vegetation. But in all cases the animals and plants composing the new kingdom of nature, though agreeing with those destroyed in their classes and genera, differed from them altogether in their species.—Lardner, *The Pre-Adamite Earth.*

These views of course rendered great compression of geological time possible, and by attributing creation to direct act of the Creator averted from their advocates the dangerous *odium theologicum.*

It is not necessary to follow into any further detail this once famous theory of Mon. E. de Beaumont. Suffice it to say that it was the popular theory when Darwin left England in 1831. He says, (p. 60) "When I was starting on the voyage of the Beagle the sagacious Henslow who, like all other geologists, believed at that time in successive cataclysms, advised me to get and study the first volume of the "Principles," which had just then been published, but on no account to accept the views therein advocated." But the crop that grew from Henslow's grain of seed was other than what the good man wished and expected. His pupil remarks, "The very first place in which I geologized convinced me of the infinite superiority of Lyell's views over those advocated in any other work then known to me."

The views of this great apostle of *uniformity*, were, in brief, that the earth since its first formation, with which he did not deal, has been continuously developing into its present condition under the influence of forces still in action aided by almost un-

limited time, and that no world-wide catastrophe has ever occured to break the chain. After contrasting at considerable length his own views with those of his predecessors he remarks:

It appears clear that the earlier geologists had not only a scanty acquaintance with existing changes, but were singularly unconscious of the amount of their ignorance. With the presumption naturally inspired by this unconsciousness they had no hesitation in deciding at once that time could never enable the existing forces of nature to work out changes of great magnitude, still less so important revolutions as are those brought to light by geology. They therefore thought themselves justified in indulging their imagination in guessing what *might* be rather than in inquiring what *is*. The course directly opposed to this method of philosophizing consists of an earnest and patient study how far geological appearances are reconcilable with the effect of changes now in progress. It also endeavours to estimate the aggregate result of ordinary operations multiplied by time. For this reason all theories are rejected which involve the assumption of sudden and violent catastrophes and revolutions of the earth and its inhabitants. *Principles*, 1853, p. 196.

This was the school of geology on which no longer than thirty years ago, theology had laid its ban, and which it denounced for heterodoxy.

It is exceedingly interesting and instructive at this point to observe the attitude of the great master of the uniformitarian school. While boldly maintaining in the face of strong and formidable opponents his theory of the slow and regular development of the earth's geography, he hesitates over the application of the same principle to the organic world. The outspoken advocate here becomes a feeble and insinuating apologist. On the question of geography Lyell gives no uncertain sound, but in the case of biology his notes are shaky. After ranging freely over whole continents of inorganic change he halts suddenly, irresolute and staggering, on the brink of the chaotic abyss that opened before him when he began to treat of changes organic. It is almost amusing to contrast the confident tone of the great teacher on the former with his uncertain utterances on the latter. In his "Principles," (Ed. 1853) the greater part of which is given to a discussion in maintenance of his views on inorganic development, he passes on, toward the close, to consideration of the fixity or mutability of species. After a long

and elaborate review of the whole subject he sums up in the following words (p. 611).

From the above consideration it appears that species have a real existence in nature, and that each was endowed at the time of its creation with the attributes and organization with which it is now distinguished.

In other words he rejects the doctrine of the transmutation of species, in favor of that of special creation, and in order to meet the objection that no such event had ever been reported, he later (p. 705) enters on an elaborate calculation of the chance of such an event having been seen by man. "If one species only of the animal kingdom died out in forty years, in a region of the dimensions of Europe, no more than one mammifer might disappear in 40,000 years.

The extreme caution that was the strongest feature in the character of Lyell is nowhere more distinctly shown than here. Could he have extended his principle of uniformity over the whole realm of creation, organic as well as inorganic, it would have given a completeness to his work which it lacked when in 1830-53 he published the earlier editions of the "Principles." But after a careful examination of Lamarck's theory of the transmutation of species, it was rejected as baseless, and, no other being then in sight, the conscientious geologist preferred letting his book go forth without what would have been to many minds its strongest attraction. He was deficient in anticipation -- that prophetic insight of science — which enables those who possess it to look ahead over dificulties and see them all clearing away before the principle, in the truth of which they firmly believe. This is one of the sublime faculties of the human mind — it develops a faith that overcomes every difficulty, silences every objection, holds its own in spite of neglect, opposition and ridicule, and at length enjoys its reward in full fruition. Such faith was not Lyell's, but it was Darwin's, and he lived to see it end in the realization of his predictions.[1]

[1] We have a parallel case at the present day. A certain school of evolutionists adopt the views of Darwin in every point but one. They admit the development by variation and selection, of all animals except man. For various reasons they hesitate to acknowledge their own descent from a lower form. In a similar condition are those who insist on the introduction of the "Deus ex machina" at the beginning of life. Their faith is not the faith of Darwin.

Such was the seed and such the field in which it was sown. The copy of the "Principles" that went on board the *Beagle* bore perhaps more and richer fruit than all the rest of the edition. We shall see its effects and the reaction of his greater pupil on the great master.

(To be continued.)

SOME OBJECTIONS TO THE TERM TACONIC CONSIDERED.

BY N. H. WINCHELL.

There is a just rule of nomenclature requiring only to be mentioned to be approved, which is applicable in considering the term Taconic. It is recognized by paleontologists, by unanimous practice, its justice being so apparent that there has never been any need to formulate it in words; *viz.* an author's own definition and description of his new species must be accepted, instead of that of other investigators, and, especially, instead of that of those who have described species nearly allied, or that might come into competition with it in any way. A corollary to this, equally self-evident, is the right that the author has to add to or modify his original description in any manner, even to abolish his species or to erect two or more from the original, unless prior to his changing it another investigator had discovered and published the necessary corrections, and had erected specific names of his own. One other well-known law of nomenclature, lately re-affirmed by the International Congress of Geologists, is that known as *the law of priority*; but priority that goes into pre-Linnæan literature (the 12th edition of Linnaeus, 1766) is considered as having no claims, as priority, and if a species from before that date be recognized it must be for other reasons. These rules of paleontologists are based on the broader right of the *ownership of the discoverer*, a right which is recognized in all science and in all law whether domestic or international, so broad and so fundamental that to generally ignore it would bring civilized countries again into barbarism, where the possession of property is dependent on the possession of brawn sufficient to defend it. It is to these rules, therefore,

that the term Taconic makes appeal, and in the light of them a few objections are here considered.

WHAT IS THE TACONIC?

Dr. Emmons officially announced it in 1842,[1] but called attention to the fact that it had been studied, and written about in the American Journal of Science many years before, the earliest mention being in 1819, by Prof. Dewey.[2] "The *Taconic System*, as its name is intended to indicate, lies along both sides of the Taconic range of mountains, whose direction is nearly north and south, or for a great distance parallel with the boundary line between the states of New York, Connecticut, Massachusetts and Vermont. * * * after passing out of the state they are found stretching through the whole length of Vermont, and into Canada, as far north as Quebec. * * * They are not a part of the former group [*The Champlain group*] in a metamorphic state. * * * We find no fossils in the rocks of which I am speaking, * * * they can be regarded in no other light than as inferior to the Potsdam sandstone. * * * the equivalent of the Lower Cambrian of Sedgwick."[3] His diagrams exhibit an unconformity at the passage of his Taconic into the rocks of the Champlain division.

In 1844, Dr. Emmons issued a pamphlet containing a revision of his Taconic system. This was subsequently included as a portion of his *Report on the Agriculture of New York*, published in 1846. In the mean time his "system" had been antagonized and severely criticised not only by his colleagues on the New York survey but by numerous other prominent geologists, who, without exception, insisted that the Taconic was the equivalent of some portions of the New York system in a metamorphic state. This objection is the same that had been urged from the first, and it was *on this point of divergence that Emmons had created his system.* Nothing new had been discovered by his

[1] Geology of New York; second district, Emmons, 1842, p. 135.

[2] American Journal of Science [1] i, 337; and ii, 246. Prof. Dewey described a section from Williamstown to Troy. This was the first section across the Taconic system. At Troy however he notes a change in the slates.

[3] Geology of New York; second district, pp. 138-163.

opponents; they simply adhered to and repeated their arguments, based on old data.[1] He, however, was not idle, but had re-examined all the facts and arguments upon which the Taconic was supposed to rest, revisiting many of the localities in the field where his earlier investigations had been made, and extending his researches to Rhode Island and Maine, and secondarily to Michigan. In this revision he greatly modified and amplified the Taconic system. He availed himself of the law which allows a paleontologist to revise his original description. He does not change in the least the original idea, *the pre-Potsdam age of the system*, but he introduces important internal re-arrangements, limits the different members, gives them different mutual relations, and describes them all more fully. He now claims that the Taconic occupies "the true paleozoic base,"— that it, and "the slates of the Cambrian," notwithstanding the announcement of Mr. Murchison that the whole of the Cambrian is covered by the Silurian, are marked by "the existence of peculiar fossils on both sides of the Atlantic." He gives diagrams of the strata that exhibit the unconformity of the Taconic with the Calciferous sandrock, the great difference in age between the Taconic and the Hudson River slates, mentioning fossils of the latter and of the Trenton within the general area of the Taconic, and calls attention to this anomalous fact. These sections run eastwardly from Whitehall, and Greenbush, N. Y. In this revision he describes and figures two new trilobites as characteristic of the Taconic—*Atops trilineatus* and *Elliptocephala asaphoides*, in which he preceded, both in the generic and the specific names, all other designations of these fossils, though the generic names have since been removed by Mr. Walcott and replaced respectively by *Ptychoparia* and *Olenellus* described several years later.[2] These are now well-known as primordial trilobites, belonging in the "Georgia formation" of Vermont. They were found by Dr. Fitch in Washington county N. Y. near the base of Bald mountain.

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[1] Among his opponents, some of whose opinions he quotes at length, Dr. Emmons mentions Mather, Hitchcock, Dana, H. D. and W. B. Rogers and Murchison.

[2] Bulletin No. 30, U. S. Geol. Surv.

Objection No. 1.

The old objection which was at the first urged against the Taconic still survives, and is urged principally by Prof. Dana. *It is the equivalent of strata above the Potsdam, and only that, and comes into conflict with the term Silurian.* Anyone who examines Prof. Dana's papers, extended through the volumes of the American Journal of Science, from 1870 to this date, will quickly learn that the basis of all his opposition to the Taconic, and the mainspring of all his able investigations in the rocks lying in Vermont and western Massachusetts, is that conception of the Taconic which he acquired in 1842, on the publication of the geological report of Emmons on the second district. This he distinctly affirms in his letter to Mr. Billings in 1872,[1] where he defines his idea of "the true Taconic." In thus restricting Mr. Emmons to his first published description of the Taconic, he violates one of the above mentioned canons of nomenclature. This is a sufficient answer to this objection, but, it appears that *even with that restriction*, if exact justice be done to Dr. Emmons, he may be allowed to include the primordial strata along with those which are post-Potsdam, in the Taconic of 1842. He defines its geographic area to extend from the Hoosic hills on the east to the limits of "the New York transition system on the west." He did not attempt to give exact geographic definition to his system in that report. It was impossible. He relied on the fundamental idea of his system, and stated that there were "great perplexities as regards the true limits of either system." (p. 137).

But Dr. Emmons had a perfect right to remodel his stratigraphic scheme, and to extend or restrict it,[2] and *no one objected to it* till 1872. It was found that at the same time with the change, he actually demonstrated, by the aid of Billings and Barrande, that his system embraced strata that were pre-Potsdam. The question whether the details of his scheme were right, or whether he "blundered" in interpreting the complex

[1] Am. Journ. Sci. (3) iii, 468.

[2] Mr. Sedgwick found similar difficulties in the stratigraphy of the Cambrian, and introduced some changes subsequent to his first description.

stratigraphy (so complex that to this day it has not been entirely unraveled,) has no bearing on the merits of this controversy. This was the view that was at once adopted by nearly all the geologists of America and Europe. It was unfortunate that in this country, at that time (1859-60), geological literature and the ways and means of expressing geological opinion were not in the control of his friends. Dr. Emmons went to North Carolina and died there during the war of the Rebellion.

Objection No. 2.

It includes strata that lie both above and below the Potsdam, and owing to the uncertainty, how much of each, the term better be abandoned. In answer to this it should be sufficient to say that if Dr. Emmons be granted the privilege of the first rule of nomenclature above-mentioned, there can be no uncertainty as to whether the Taconic embraces post-Potsdam strata. He expressly exempts all post-Potsdam strata. He calls attention to the existence of post-Potsdam fossils in the general area described as Taconic. The stratigraphic uncertainty which is here alleged is that which has been created by his opponents, and principally by those who insist that his original definition of the Taconic is the only valid one. Furthermore the geographic uncertainty is rapidly disappearing. It began to decline when Logan admitted that "there must be a break," and finally disclosed the "great Appalachian fault." It has rapidly diminished, and has now almost disappeared, under the enlightening researches of Dana, Ford, Dwight, Walcott and others.

Objection No. 3.

It is the equivalent of the "Lower Potsdam," recognized by Billings, which is the older designation. Admitted; but the term *Lower Potsdam* had no right to exist. It was a go-between, intended to avoid taking sides, and was abandoned by Billings. The great Georgia formation or the "Lower Potsdam," according to Mr. Walcott contains the fauna of the upper Taconic of Emmons and this fauna includes in America no less than forty-three genera and one hundred and seven species of primordial fossils.[1]

[1] Bulletin No. 30, U. S. Geol. Survey.

Objection No. 4.

It is partly Archæan and partly primordial and cannot be assigned to any definite horizon. Dr. T. Sterry Hunt has insisted on a "Taconian" formation, lower than the primordial zone. He has steadfastly sustained the Taconic system, but has divided it between the "Taconian" and the primordial. This downward extension of the Taconic into an Archæan terrane seems, however, to have been negatived by the recent researches of Mr. C. D. Walcott, who has stated that the lowest portion of the Taconic of Emmons contains primordial fossils,[1] and belongs to the "Georgia" formation.

Objection No. 5.

The term better be abandoned because it has caused trouble enough already. It would be an analogous reply to insist on its adoption, because its rejection has caused trouble enough already. But whether rejection or adoption be the result, the trouble that may be caused in reaching a settlement, should play no part in the process. The arbitrary suppression of an unsettled problem in science, is not the best step to insure quiet, and obviate "trouble." The scientific spirit scorns "trouble," and attacks the most mountainous obstacles. The "trouble" must be suppressed by a correct solution and a just settlement.

Objection No. 6.

It is an inheritance of the dim and distant past, and cannot be understood with any unanimity by the present generation. It is pre-Linnæan and mythical. It is to be admitted that the term is a trifle older than the terms Cambrian and Hudson River, as a semi-geological designation,[2] but it was officially published first in 1842, and many American geologists now living were present at its birth. The literature is all extant. Every fact can be avouched or disproved. It is mythical, moreover, only to those who are opposed to its recognition.

Objection No. 7.

The Taconic is primordial, and later in use than the Cam-

[1] Am. Journal of Science. (3), xxxiii, 153.

[2] Notes on classification and nomenclature. N. H. Winchell, Am. Naturalist, August, 1887.

brian, and was so admitted by Dr. Emmons. Hence Cambrian should be used instead. It is true that Dr. Emmons employed the following words in his first publication of the Taconic system: "The Taconic rocks appear to be equivalent to the Lower Cambrian of Prof. Sedgwick, and are alone entitled to the consideration of belonging to this system, the upper portion being the lower part of the Silurian system."[1] Prof. Dana has interpreted this to mean[2] that Emmons would divide his system between the Cambrian and the Silurian. By "upper portion" Prof. Dana would have Dr. Emmons imply the upper portion of the Taconic, at a time when he had not yet introduced any division into upper and lower Taconic. But that is not what Mr. Emmons intended to say. He intended to express his sympathy with Mr. Murchison by saying that the upper portion of the Cambrian was the same as the lower part of the Silurian, and that the Lower Cambrian rocks of Wales were the only ones entitled to the consideration of belonging to the Taconic system. The expression is ambiguous, but its true meaning would be made evident if instead of "and" Dr. Emmons had used the relative word *which*, so that the clause would read *which are alone entitled to the consideration of belonging to this system.* This statement of Dr. Emmons has been taken to mean that he recognized, and intended to express, the priority of the term Cambrian. But this is a forced, and not a legitimate inference. Two collaborators on a subject may refer back and forth to each other's work without involving the question of priority. Mr. Sedgwick in 1855 could have referred in the same terms to the Taconic without implicating himself in the question of priority. He could have said with perfect propriety "The Lower Cambrian rocks appear to be equivalent to the Taconic of Dr. Emmons," and he would not thereby necessarily have given assent to the priority of the Taconic. On the contrary, Dr. Emmons simply desired to exemplify by a comparison with a formation which Prof. Sedgwick was working on, his own Taconic system. He had known the Taconic rocks for twenty years. He had read the treatises of Dewey, Hitchcock and Eaton in the American Journal of Science since 1819,

[1] Geol. of New York, 2nd district, p. 163.

[2] Am. Journ. Sci. (3) iii, 469.

all dwelling at length on the "rocks of the Taconic range," grouped as a distinct terrane, and it is not probable that, with that exact knowledge he had of current literature, American and European, he would have fallen into such an anachronism. The most that can be claimed adverse to the Taconic, based on this expression, is that Dr. Emmons admitted that at the date of the writing of his official report he knew that the Cambrian had been announced by Sedgwick. But the "rocks of the Taconic range" had been well known under that designation, long before they were specifically erected into the Taconic system. That designation had the same force, and as much right to recognition as a geological entity, as a similar use of the term "rocks of the Longmynd hills," or "rocks of the Helderberg mountains." One became, by an easy change in terminology the *Longmyud rocks*, and the *upper* and *lower Helderberg rocks*, and the other was changed to *Taconic system*.

This objection could be answered further by saying that the Cambrian as defined by Sedgwick did not include a primordial fauna, and was not intended to, and has no right therefore to it. Its place is the horizon of the second fauna.[1] Its stratigraphic scheme included rocks both of the first and of the second faunas, but Sedgwick would not admit that his Cambrian included any of the primordial rocks. A similar mistake was made by Dr. Emmons. His stratigraphic scheme included rocks both of the first and second faunas, but he carefully exempts from it all strata known by him to contain the second fauna. *Emmons aimed to erect the primordial rocks into the Taconic system. Sedgwick aimed to erect the second fauna rocks into the Cambrian system.* After eliminating like mistakes from the labors of these pioneers there is a residuum of fact and correct historic interpretation which assigns the Taconic to the first fauna and the Cambrian to the second.[2]

Objection No. 8.

The primordial strata to which the name may be applied do not exist in the Taconic range of mountains and the name is

[1] British paleozoic fossils, Sedgwick and McCoy, 1855.

[2] Notes on classfication and nomenclature. N. H. Winchell. *American Naturalist*, August, 1887, p. 693.

inappropriate for that reason. It is legitimate here to enquire what constitutes the Taconic mountains. Fortunately some old maps and definitions of the Taconic mountains exist. Dr. Emmons constructed a geological map of the state of New York in 1844, intended to accompany his report on the Agriculture of New York, but it was never distributed with that volume, and although printed and delivered by the contractors it had been lost.[1] In the recent removal of some of the effects of the New York State Museum into the old capitol at Albany the edition was found stored away in a neglected room, and the most of it is now in the possession of professor James Hall, who in April, 1887, distributed copies to the American committee of the International Congress of Geologists. This map shows the distribution of the Taconic rocks according to the ideas of Dr. Emmons. It is a reprint, in the main, of the map which accompanied the first reports, but is changed in the eastern part, to represent the Taconic system. This extends in a belt from the south covering Columbia, Rensselaer, and Washington counties, and, passing into Vermont, forms a belt along the east side of lake Champlain and runs into Canada. Topography is a subordinate feature of this map, but the main mass of the Taconic mountains is shown on the boundary line between New York and Massachusetts. His description in 1842 (Geology of the cond district, p. 136) is in these words: "Lies along both sides of the Taconic range of mountains, whose direction is nearly north and south or for a great distance *parallel with the boundary line* between the states of New York, Connecticut, Massachusetts and Vermont." His description in 1844 contains these words: "In Massachusetts and Vermont, as in New York, what has usually been denominated the *primary range* skirts the Taconic system upon the east, and forms with it, parallel belts of low mountain ranges." Nothing farther is needed to show that Dr. Emmons regarded the Taconic hills as extending in subordinate spurs and ridges, from the typical region many miles further north, passing into Rensselaer and Washing-

[1] Dr. Emmons in some later correspondence referred to the disappearance of this map, and intimated that it has been surreptitiouslyde-stroyed.

ton counties; and if it were needed it would only be necessary to refer to his having placed Bald Mountain,[1] and Mt. Toby, which are in Washington county, the former the locality noted for the first primordial fossil ever discovered and identified, within the range of the Taconic. Further, Dr. Emmons in refering to the Magnesian slate member of the Taconic, says a "range of mountains composed of this slate extends along the western border of Massachusetts and through Vermont. It often rises to the hight of 1500 feet. This range is known as the *Taconic range*, and has furnshed the name to the system of rocks I am describing."[2] Comparing this statement with the geological map designed to acompany the volume, it will be seen at once that in order to follow the Taconic range from the place they are represented into western Vermont, it must pass through Rensselaer and Washington counties, and hence must include Bald mountain. Therefore the objection is baseless, because the primordial rocks do occur in at least one point in the Taconic range.

Again, it would be premature to exclude the primordial strata from the principal part of the Taconic range—*viz.* those hills situated on the boundary line between New York and Massachusetts. The trend of the discoveries of Mr. Dana and Mr. Dwight, it should be admitted, is toward such exclusion; but until those hills have been subjected to a searching inspection of their structure, no geologist can affirm with safety that no primordial rocks occur there. The very fact that here the hills rise to greater hight and embrace far more bulk than elsewhere indicates some interruption or irregularity in the strata, and if the

[1] The map of Dr. Asa Fitch, accompanying his treatise on Washington county in 1849, shows two "Bald" mountains, one in Greenwich and one at the N. W. corner of Hebron, but the former is the primordial locality. This map shows the country mountainous, with low spurs of the northern extension of the Taconic hills.

In the final report on the the Geology of Vermont, vol. ii, p. 873, is a description of the Taconic mountains in Vermont in which they are said to run parallel with the Green mountains, and in the southern part of the state to be separated into several series that are apparently wholly independent of each other, similar to their appearance in Washington county, New York.

[2] Agriculture of New York, p. 77.

lower hills immediately to the N. E. and S. W. from this main mass embrace only strata of the second fauna, there is the more reason to expect other terranes involved in the mountains themselves.

These objections to the term Taconic being thus obviated we may at least fairly adopt the conclusion arrived at by Mr. Walcott after careful field examination and study of the fossils.

1. After deducting all the errors the upper Taconic remains as a distinct formation beneath the horizon of the Potsdam sandstone.[1]

2. The term Taconic is applicable to American strata carrying the first or primordial fauna, unless Cambrian has a clear priority of usage.[2]

ANTHRACITE COAL IN THE VALLEY OF THE BOW RIVER, NORTHWEST TERRITORY OF CANADA.

BY PROF. JAMES A. DODGE.

I have recently made an analysis of a sample of coal received from "The Canadian Anthracite Company," for Mr. A. Pugh, Gen'l Manager, St. Paul, Minn. I have Mr. Pugh's consent to make the matter public, and at my request he has given me some facts as to the locality from which this sample of coal was obtained.

The coal has all the appearance of anthracite. The analysis made by me was not a complete elementary analysis, but such as I have usually made to determine the character of samples of coal.

ANALYSIS.

Volatile matter	2.64 per cent.
Fixed carbon	86.28 "
Ash	11.07 "

The pulverized coal was dried at 100° C. before analysis. The loss by drying was scarcely appreciable.

Taking out the ash from the preceding results, and calculating to ash-free substance, we have the following figures:

Volatile matter	2.97 per cent.
Fixed carbon	97.93 "

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[1] Bulletin No. 30, U. S. Geol. Sur., p. 70.

[2] American Journal of Science, (3) xxxiii, 153.

The analysis thus shows that the coal is veritable anthracite.

From the letter of Mr. Pugh, I take the following statements.

"This coal basin lies in the valley of the Bow river, in the Province of Alberta, Northwest Territory of Canada. We have prospected the croppings on the north edge of the basin for something like twenty miles. There are a number of seams, perhaps twenty or more, in the basin, varying in thickness from an inch to fifty feet. * * * These veins all dip to the south from thirty-two to forty-five degrees, and have a sandstone bottom and slate roof." * * * "We have made an opening above water level and driven a tunnel 209 ft. at right angles with the coal seams, and have driven 3,500 ft. of gangways and the same number of feet of headings and airways." "We have machinery for breaking and preparing the coal on the ground." "We have mined, perhaps, 5,000 tons, most of which has been sent to the Pacific coast."

I understand that the Canadian Pacific Railway runs through the basin above referred to.

Minneapolis, Feb. 20, 1888.

A GREAT PRIMORDIAL QUARTZYTE.

BY N. H. WINCHELL.

The recent announcement by Mr. Walcott that the "Granular quartz" of the Taconic system contains the fauna of the Georgia slates of Vermont, provokes a series of reflections that lead to interesting and probable generalizations respecting the equivalents of the Granular Quartz in other parts of the country.

The Granular quartz of Dr. Emmons' Taconic forms a mountain range extending northward, through Pownal, Wallingford, and Bristol to Starksboro, Vermont, where, according to the geologists of the Vermont survey, it terminates abruptly, and the name is changed without any intervening strata, to "Red sandrock," and as a red sandrock it constitutes, in their opinion, an independent series of mountains, but really unites with another spur of the same coming from the southwest. The combined series then extends northward constituting the "Red sandrock"

mountains. Prof. Emmons regarded these quartzose rocks as distinct, and the Red sandsrock as the Potsdam sandstone. But there never has been given any good reason for separating them, and it seems now that the work of Mr. Walcott has indissolubly united them as one and the same formation. Barrande and Billings called attention first to the primordial character of the fossils contained in the Red sandstone at Georgia, Vermont, and from that time to this there has been a steady increase in that fauna, until now it is regarded as the chief member of the primordial in America.

If the "red sandrock," and the granular quartz," constituting a mass of hard quartzyte which has a thickness of over a thousand feet, be followed westwardly, it is found to rise on the west side of lake Champlain, and, with a short spur extending into Canada, sweeps along the northern and northwestern borders of the Adirondack mountains, affording large outcrops on the Racket river, and important quarries at Potsdam, in St. Lawrence county. Here it has been described by Dr. Emmons and named "Potsdam sandstone." His description is so exact and so important that it should be given wide publication.[1]

I shall not enter upon its geological relations, any further than to state that in Potsdam, and other towns in which it appears, it uniformly rests on the primary strata; and in no part of the country is there any rock which interposes itself between it and the primary, so that it appears here as the oldest representative of the transition series. The identification of this rock with the sandstones along the south border of lake Ontario will be a matter of some difficulty. It is geologically below the transition limestone, and never in the northern district alternates with it, but always holds the relation of an inferior rock. So much is known of its position, but still some doubt remains as to its general relation and to its name and place in the series of rocks. Some call it the old red sandstone; others regard it as equivalent to the new, or saliferous rock of Eaton. But our business is to describe the rock as it is, and speak of its economical applications, leaving some doubtful points to be cleared up by future observations.

This rock is a true sandstone, of a red, yellowish-red, gray and grayish white colors. It is made up of grains of sand and held together without cement [sic]. Intermixed with the siliceous grains are finer particles of yellowish feldspar, which do not essentially change the character of the sandstone, but they show the probable source from which the materials forming it were originally derived, viz. some of the varieties of granite.

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[1] Annual report of the geological survey of New York for 1837, p. 214.

Unlike, however, most of the sandstones, it is destitute of scales of mica. The coloring matter of the rock is evidently oxide of iron, but unequally diffused through it, giving it intensity or deepness of color in proportion to its quantity. In some places it is almost wanting, which makes it, when pulverized, a good material for glass, The grains and particles in its composition are generally angular, but where it takes the character of a conglomerate, as it does in the inferior layers, they are frequently rounded. The thicker strata exhibit an obscurely striped appearance, owing to prevalence of certain colors in different layers.

Two properties possessed by this sandstone increase essentially its value for all purposes to which it can be applied—its durability which is owing to its siliceous character, its evenness of grain and strata which facilitates and lessons the labor of quarrying and afterwards saves the expense of dressing preparatory to its employment as a building material. Both of these characters fit it admirably for every kind of use to which stone is ever required. As a firestone nothing can be found better, and if it is required for durable public works, as the locks of canals, etc., no material can be found better suited for the purpose.

The strata of Racket river, where the principal quarries are opened, rise about 65 or 70 feet above the river. The quarries extend some ten miles along this river, which has apparently cut through the rock and exposed the strata on each side, dipping to the northwest at an angle of about 30 degrees. I have not ascertained the whole thickness of the beds. The layers vary in thickness from half an inch to four feet, so that every variety may be obtained; and the thicker strata may be split to any required thickness for which they may be wanted. Slabs having any superficial area which can be used, and of the given thickness, may be quarried with ease. The waters from which this sedimentary rock were formed, most have been in a perfectly tranquil state to have preserved such a regularity and. evenness of surface and freedom from contortion. Such a state did not prevail everywhere, even in the immediate vicinity of Potsdam, for at DeKalb, in the same formation, there are some very remarkable contortions and disturbances. * * * * It appears that when the strata were elevated they were frequently fractured for miles in a north and south direction, and along the line of the greatest uplift they were in one sense comminuted, or broken into small pieces. Subsequently currents of water passing over the whole region further broke up and carried away all the loose materials. The result of the combined effects of the uplift and of the currents has been the production of long narrow valleys, bounded on both sides by perpendicular walls of sandstone, which still stand, in many instances like regular mason work. The fractures usually extend down to the primary strata, and the whole stratum of sandstone has been sometimes removed to the gneiss and granite.

That the above is not hypothetical is evident from the rounded corners of those portions of the strata which lie along these valleys and also from the scratches they received, and which still remain as perfect and fresh

as if they were made yesterday.[1] Fig. 12 [not re-produced] is a transverse section of one of the valleys described above. The walls on either side are rounded and scratched. Their depth varies from 10 to 100 feet.

The sandstone of Potsdam bears a land transportation of from 15 to 20 miles; and at these distances from the quarries it is considered as cheap a material for building as brick, and I venture to say there is no stone in the state, or anywhere else, equal to it for durability. As regards beauty individuals may differ, but there is no stone superior to it in this respect, unless it is marble. All the sandstones and freestones which are brought to the New York and Albany markets, crumble more or less, and suffer eventually from the weather, but this will resist attacks of all the natural agents to which it may be exposed. * * * As a firestone the Potsdam sandstone is held in the highest repute. Composed as it is of siliceous grains, compacted together by compression, it is calculated to resist the highest degree of heat; and as it is uncrystallized it is not liable to crack by this exposure. All the furnaces of St. Lawrence and Jefferson counties have their hearths of this sandstone. Another use to which I conceive this stone may be applied, is for grinding hard bodies, and perhaps it may answer for coarse grindstones, and for some particular offices where a certain degree of hardness is required it may be superior to the ordinary stones.

From this place this formation strikes across the St. Lawrence river toward the northwest, and is represented as far west as Bedford in the county of Frontenac, on the geological map of Canada, 1863.

Thence westward it is lost, and the country is represented as occupied by the Laurentian. A formation of its persistency of character and thickens however can hardly be expected to disappear so soon, and it is the purpose of this paper to call attention to the great probability that the great primordial quartzyte of Minnesota and Wisconsin is the same as that described by Dr. Emmons at Potsdam.

In the first place all the physical characters that are mentioned by Dr. Emmons, and those that are given by Prof. Hitchcock in the Vermont reports, as belonging to and characterizing the "sandstone of Potsdam," are perfectly applicable to the quartzyte seen at Pipestone, Minnesota, and the same in Barron county, Wisconsin. One might take the description of Dr. Emmons in his hand, and, standing on the quartzyte ranges of

[1] Dr. Emmons is here evidently describing the well known glacial striæ which are every where beautifully preserved on this rock throughout the Northwest.

southwestern Minnesota, he could read a perfect account of the rock he was standing on. I would refer the reader to the first annual report of the Minnesota geological survey for a somewhat detailed comparison of these widely separate areas of this great formation. This similarity was forcibly brought to the attention of the writer again in 1884 when at New Orleans. The State of New York had on exhibition there, with other things, a set of rock samples. The Potsdam sandstone was represented by a block a foot square and abont eighti nches thick. Struck with the great resemblance it bore to the Pipestone quartzyte of Minnesota I solicited of Mr. C. E Hall who had the specimens in charge, and received from him the donation of this block to the muesum of the University of Minnesota. On being placed alongside of similar blocks of quartzyte from Minnesota, it cannot be said to differ in any particular. It is red, with some interrupted stripings of light red, but it is a compact though granular quartzyte, and hardly worthy of the name sandstone. When subsequently the discovery of a primordial fauna was made in the red quartzyte at Pipestone[1] there seemed to be lacking no important evidence to parallelize these outcrops.[2]

In July, 1887, the writer visited and evamined the rocks of the "original Huronian." He was at once convinced of the perfect parallelism of the great quartzyte there displayed with the quartzyte of Wisconsin and Minnesota, as claimed by the geologists of Wisconsin. Some of the details of this similarity will be given in a subsequent paper; and in so far as that identity goes he was convinced that the Minnesota quartzytes also are Huronian. But what then is this Huronian quartzyte other than the Potsdam sandstone of New York, the red sandrock of Vermont, and the granular quartz of the Tacnoic? Things that are equal to the same thing an equal to each other. The Huronian, so far as this quartzyte is concerned, is a part of the Taconic; and the Potsdam itself is the same, notwithstanding the contrary protestation of Emmons, and in harmony with the conclusions of the geologists of the Vermont survey.

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[1] Thirteenth annual report of the geological and natural history survey of Minnesota.

[2] The Potsdam sandstone is used in the new part of Columbia college in New York City.

What do we have then?—a great primordial quartzyte, which under different names extends from New England, through Canada, into Wisconsin, Minnesota and to the Black Hills of Dakota. It has also been identified further west, making it in American geology truly a continental formation, whose simple, persistent and uniform characters not only render it readily recognizable but impart to it that feature which all continental formations possess.

Many important and interesting corollaries spring from this generalization.

1. The Potsdam, as claimed by Profs. Hitchcock and Jules Marcou, is a part of the Taconic.

2. The Huronian is the equivalent of the Taconic, at least so far as the common possession of this quartzyte makes them identical.

3. The Barraboo quartzyte, the Barron county quartzyte, the Wauswaugoning quartzyte, the Sioux quartzyte and the Black Hills quartzyte are identical parts of the Taconic.

4. This would leave the "black slate" of Bald mountain and the "Taconic slate" as the only portions of the Taconic not proven to be equivalents of some parts of the New York series; and if Mr. Walcott's inference that these slates are the deep-water equivalents of the off-shore deposits of the "granular quartz" be correct, no part of the Taconic would remain as an independent formation.

5. If, however, the succession of strata east of the Adirondack mountains is the same as in the area of the original Huronian and in northeastern Minnesota, this great quartzyte immediately overlies, in some places, a black slate and in others it lies unconformably on granite; hence the granular quartz of Emmons probably belongs above his black slate.

6. The Potsdam quartzyte-sandstone should be sought for not only in that part of Canada where it has been represented as wanting, but also in northern Michigan where it has been supposed to be represented by the "eastern sandstones."

A CORRELATION OF THE LOWER SILURIAN HORIZONS OF TENNESEE AND OF THE OHIO AND MISSISSIPPI VALLEYS WITH THOSE OF NEW YORK AND CANADA.

BY E. O. ULRICH.

(Continued from the February number.)

Beds VIII. These beds, though in both features somewhat variable, are easily distinguished from the preceding by their composition and color. Their maximum thickness in central Kentucky where they have been studied in Mercer, Henry, and Fayette counties, is apparently not over twenty feet, and seems sometimes to be considerably less. The upper half, consisting of heavy bedded, gray, granular limestone, is the variable member. Its fossils also are few and badly preserved. The lower half seems more constant in its thickness, and consists of less coarsely granular, thin and evenly bedded layers.

Some of the layers of this division are readily decomposed by carbonated waters, causing subterranean cavities to be formed, which in turn give rise to large springs. The latter sometimes open at the bottom of deep holes; at other times they pour in greater or less volume from the sides of small cliffs.

The fossils, as already stated, are few and usually unfit for fine discrimination, being in most cases either roughly silicified or largely destroyed by granulation. Still, in the lower portion, the surfaces of some of the thinnest layers are nearly filled with the shells of a thin and nearly flat form of *Strophomena*, and other fossils. Of those that conld be determined the following are of interest in this connection:

Buthotrephis? succulens Hall.	*Glyptocrinus ramulosus?* Bill.
Girvanella sp. a.	*Zygospira recurvirostris* Hall.
Hindia sp. a.	*Orthisina sp. a*

Beds IX. This division in its lithological characters somewhat resembles the upper half of bed IV, and like it seems to be rather local in its distribution. Its thickness in Mercer and Boyle counties where it is more distinct than elsewhere, is probably not greater than fifteen feet. The layers are massive, subcrystalline or granular, of a grayish color, and charged with cellulose chert and silicified fossils. The rock disintegrates rapidly and is covered with a thick layer of light red soil, from which

the rains wash out the chert and fossils. The latter are in a beautiful state of preservation and belong to numerous species, the Gasteropoda being the best represented.

The best exposure of this horizon seen was found in a cut along the Cincinnati Southern R. R. at a point about one mile and a half south of Burgin, Ky. Several good exposures were also met with in the vicinity of Lexington, Ky.

The following is a list of the principal fossils:

Buthotrephis? succulens Hall.
Stromatocerium pustulosum Safford.
Phylloporina granistriata Ul.
Orthis testudinaria (very thin form)
Zygospira recurvirostris Hall.
Rhynchonella increbescens Hall.

Bellerophon troosti Safford (Rare.)
" *socialis* n. sp.
" *lindsleyi* Safford.
" *acuta* Sowerby.
Cyrtolites ornatus Conrad.
Metoptoma ungula n. sp.
Pleurotomaria (*Raphistoma*) *subtilistriata* Hall.
Pleurotomaria n. sp. *a.*
Murchisonia gyrogonia McCoy.

Murchisonia pulchra McCoy.
" *sumnerensis* Safford.
Holopea obliqua Hall.
Cyclora depressa? Ulrich.
" *minuta* Hall.
" *parvula* Hall.

Ambonychia intermedia M. and W.
Tellinomya sp. closely related to *T. nasuta* Hall. but larger and higher.
Cypricardites wortheni n. sp.[1]
" *haynina* Safford.
Matheria tener Bill.
Modiolopsis nais Bill.
Conocardium immaturum Bill.
Dalmanites callicephalus Green.

Beds X. To these Mr. Linney has applied the provisional name "Upper Birds-eye beds." They have a maximum thickness in Mercer and Boyle counties of about twenty-five feet, and consist mainly of firm, light or dark dove-colored limestones, in from one to two feet layers, with some of them separated by thin seams of shale. Toward the top the layers are lumpy and change in color into gray and then bluish, showing also signs of slight disturbances. The uppermost layer is generally distinguished by the large masses of *Stromatocerium* (*?Labechia*) *pustulosum* Safford, which abound in it, while the two or three feet below it contain numerous compressed valves and complete shells of *Orthis borealis* Billings, and *Rhynchonella increbescens* Hall. The dove-colored layers, in their compact texture and "Birdseye" structure, closely resemble those described in this paper as beds III. Some of them, the darker ones in particular, hold large numbers of *Leperditia* and *Isoch-*

[1] This name is proposed for the shell of which an internal cast is figured and described in vol. iii. of the Ill. Geol. Surv. p. 311, plate 3, figs 9*a*-9*d*. Several fine specimens have been obtained from these beds.

ilina, but other fossils are rare. Near the bottom there is a massive subcrystalline layer, holding an abundance of *Cyrtadanta*, *Tellinomya Bellerophon troosti*, Safford, and *Murchisonia gracilis* Salter (?Hall). The fossils in this layer are silicified and well preserved. Near the top, again, there is often another layer in which the fossils are siliceous, and in which several of those found in lower layers reappear associated with fine examples of *Tetradium fibratum*.

Of the thirty or more species of fossils that have been collected from these beds the following should be mentioned:

Buthotrephis? succulens Hall.
Tetradium fibratum Safford.
" *minor?* Safford.
" *columnare* Hall.
Stictopora paupera Ulrich.
Zygospira recurvirostris Hall.
" *modesta* Say, (seems to have modified from the preceding).
Rhynchonella increbescens Hall.
" *procteri*, n. sp. (Like *R. dentata* Hall, but narrower and with much more prominent and less incurved beak.)
Bellerophon troosti, Safford.*
Carinaropsis cunulae Hall.
Pleurotomaria eugenia Billings.
Murchisonia bilicincta Hall
" *gracilis* Salter (? Hall).
" *sumnerensis* Safford.
Tellinomya hartsvillensis Safford.
Cypricardites trentonensis n. sp.
Leperditia armata Walcott.
" *josephana* Jones.
Isochilina jonesi Wetherby.

The beds designated as VIII, IX, X, probably constitute local divisions of a single series of strata, As, however, south of the Kentucky river in central Kentucky each is marked by its own lithological peculiarities as well as by a largely different fauna, it seems desirable to treat them separately. In tracing them to the north they decrease in thickness and seem to loose their identity, or one or two of the members run out.

Thus, at Lexington, though still distinguishable, they are nevertheless more intimately connected and thinner than in Mercer and Boyle counties. At Cincinnati, as shown by deep well borings, they are represented by only twenty feet of exceedingly tough, bluish-drab, limestone, indicating that the upper division is the most persistent. In northern Indiana they appear to be still further reduced, the hard cap of the Trenton being, according to the reports of the drillers, often less than five feet thick.

Some beds exposed in the bank of the Ohio river at Point Pleasant, about twenty-one miles south east of the mouth of the Licking river opposite Cincinnati O., are referred to this horizon.

They have been but little studied and so far as known, contain but few fossils, still, enongh has been learned to prove them older than any exposed at Cincinnati.

In central Kentucky the beds under consideration, (particularly the upper member) are known to contain deposits of barytes, lead, and zinc, while some of the layers are occasionally porous, and hold small cavities filled with petroleum. A thin layer of sandstone is also present. Whether the recent flow of gas and oil in Ohio and Indiana is derived from them or from the equivalent of the "Blue Grass" beds immediately below them, is an interesting point that remains as yet undetermined.

The ten beds or divisions so far treated, with the exception of VI and VII, consist mainly of more or less heavy bedded limestones. On the other hand, in the succeeding beds of the Lower Silurian series of this area, soft, bluish shales or marls predominate, and layers of limestone over a foot in thickness are very rare. This lithological change is accompanied by an equally marked change in the fauna, since but a few species, comparatively, are common to beds X and succeeding deposits.

The series intervening between beds X and the overlying Upper Silurian rocks have been the subject of much discussion. In the Ohio geological reports, Prof. Orton divides them into two sections, which he calls the Cincinnati and Lebanon beds. The first he again subdivides into three portions named, in ascending order, River Quarry beds, Eden shales, aud Hill Quarry beds.

In the later Kentucky reports Mr. Linney and others divide the series into three sections which they call the lower, middle and upper Hudson beds.

Contrary to the plan usually pursued, several reasons induced me to begin their discussion with a tabulated list of the fossils whose range in them has been approximately determined. The list embraces but a few more than half of the number of species known to me, but as the unnoticed forms are in most cases new, doubtfully identified, or not fully understood, they could not properly be included. Many of them, the undescribed forms especially, are characteristic of one or the other of the divisions, and they doubtlessly more than off-set the number which future

research may show to be less restricted in their range than given.

First, however, it is necessary to state that I divide the series into four principal divisions, which in part agree with those adopted by both the Ohio and Kentucky geologists. They are based upon recognizable though not sharply distinguished lithological peculiarities, and upon more pronounced faunal differences. The lower two divisions are each again subdivided into two minor sections, distinguished as *a* and *b*. All of these divisions will be considered in detail later on.

TABLE OF THE PRINCIPAL FOSSILS OF BEDS XI, XII, XIII AND XIV, SHOWING THEIR DISTRIBUTION AND RANGE.

		Species in Lower Beds.	*Beds XI*		*Beds XII*		*Beds XIII.*	*Beds XIV.*
			a	*b*	*a*	*b*		
1	Buthotrephis gracilis Hall	*	*	*	*	*	*	*
2	" ramulosa S. A. Miller		*					
3	" flexuosa Hall		*	*				
4	Palaeophycus rugosum Hall	*	*					
5	" ? virgatus Hall						*	
6	Licrophycus flabellum Miller and Dyer				*	*		
7	Dactylophycus tridigitatum M. and D			*				
8	Heliophycus stelliforme M. and D					*		
9	Lockeia siliquaria James		*					
10	Rusophycus bilobatum Hall		*	*	*	*	*	*
11	" pudicum Hall				*			
12	Cyclophycus laterale Ulrich Ms		*					
13	Sphenophyllum primaevum Lesq			*				
14	Calathium sp							*
15	Discophycus typicalis Walcott				*			
16	Dystactospongia insoleus Miller				?*	*		
17	Patersonia difficilis Miller				?*	*		
18	Heterspongia subramosa Ulrich				*	?*		
19	Stromatocerium pustulosum Safford	*						*
20	Beatricea nodulosa Billings							*
21	" undulata Billings							*
22	Labechia ohioensis Nicholson						*	
23	" montifera Ulrich						*	
24	Girvanella richmondensis Miller							*
25	Solenopora compacta Billings	*			*	*		*
26	Palaeophyllum divaricans Nicholson						*	*
27	Zaphrentis canadensis Billings						*	*
28	Columnaria alveolata Goldfuss							*
29	Columnaria halli Nicholson	*					*	*
30	" calicina Nicholson							*
31	Columnopora cribriformis Nich.						*	*
32	Protorea vetusta ?Hall						*	*
33	Tetradium approximatum Ulrich						*	*
34	" fibratum Safford	*	*					
35	Graptolithus gracilis Hall		*					
36	" tenuis? Portlock		*					
37	Dendrograptus gracillimus Lesq			*				
38	" tenuiramosus, Walcott			*				
39	Dicranograptus ramosus Hall		*					
40	Diplograptus whitfieldi Hall		*					
41	" spinulosus Hall		*					
42	Climacograptus typicalis Hall		*	*				

		L. B.	XI		XII		XIII	XIV
			a	b	a	b		
43	Inocaulis arbuscula Ulrich			*				
44	Megalograptus welchi Miller	*					*	
45	Glyptocrinus decadactylus Hall				*			
46	" " var. with long basals	*	*	*				
47	" dyeri Meek					*		
48	" subglobosus Meek					*		
49	" shafferi Miller					*		
50	" sculptilis Miller						*	
51	" ? parvus Hall			*	*	*		
52	" miamiensis Miller						*	
53	Reteocrinus oncalli Hall						*	
54	" magnificus Miller						*	
55	Canistrocrinus pattersoni Miller		*					
56	" richardsoni Wetherby						*	
57	Mariacrinus harrisi Miller						*	
58	Xenocrinus baeri Meek						*	
59	" pencillus Miller						*	
60	Heterocrinus simplex Hall		*	*				
61	" grandis Meek				*			
62	" canadensis Billings	*	*	*				
63	Stenocrinus heterodactylus Hall		*	*				
64	" propincuus Meek		*	*				
65	" ? geniculatus Ulrich		*					
66	" pentagonus Ulrich					*		
67	Ohiocrinus constrictus Hall					*		
68	" laxus Hall					*		
69	Iocrinus subcrassus M. and W.				*	*		
70	Anomalocrinus caponiformis Lyon					*		
71	Dendrocrinus cincinnatiensis Meek					*		
72	" casei						*	
73	" dyeri Meek		*					
74	" polydactylus Shumard						*	*
75	Merocrinus curtis Ulrich		*					
76	Lepocrinites moorei Meek							*
77	Agelacrinites cincinnatiensis Roemer				*	*		
78	" pileus Hall				*			
79	" vorticellatus Hall				*	*		
80	Hemicystites granulatus Hall				*			
81	" stellatus Hall				*			
82	Lichenocrinus dubius Miller		*					
83	" pattersoni Miller		*					
84	" tuberculatus Miller							*
85	" affinis Miller						*	?*
86	Cyclocystoides mundulus M. and D.					*		
87	Palaeaster finei Ulrich		*					
88	Taeniaster fimbriata Ulrich		?*	*				
89	" flexuosa M. and D.		?*	*				
90	Rhopalonaria venosa Ulrich			*			*	
91	Stomatopora inflata Hall		*	*	*	*	*	*
92	" arachnoidea Hall		*	*	*	*	*	*
93	" proutana Miller		?*	*	*	*	*	?*
94	" frondosa Nich.				*			
95	Berenicia vesiculosa Ulrich		*	*				
96	" primitiva Ulrich					*	*	
97	Monticulipora cincinnatiensis James					*		
98	" mammulata d'Orb				*	*		*
99	" molesta Nich.					*		
100	" parasitica Ulrich							*
101	" lævis Ulrich						*	*
102	Atactoporella mundula Ulrich				*			
103	" multigranosa Ulrich					*		
104	" ortoni Nicholson					*		
105	" tenella Ulrich					*		
106	" schucherti Ulrich						*	
107	" typicalis Ulrich	?*	*	*				
108	" newportensis Ulrich			*				
109	Peronopora compressa Ulrich					*		
110	" decipiens Rominger					*	*	*
111	" vera Ulrich		*	*	*			
112	Homotrypa curvata Ulrich				*			
113	" dawsoni Nicholson					?*	*	

No.	Species	L. B.	XI a	XI b	XII a	XII b	XIII	XIV
114	**Homotrypa** obliqua Ulrich					*		
115	" multituberculata Whitfield							*
116	**Heterotrypa** frondosa d'Orb				*			
117	" var. *a*					*		
118	" inflecta Ulrich					*		
119	" prolifica Ulrich						*	*
120	" solitaria Ulrich				*			
121	" subpulchella Nich				*			
122	Dekayia aspera Ed. and Haime				*			
123	" appressa Ulrich					*		
124	Dekayia paupera Ulrich					*		
125	Dekayella obscura Ulrich			*				
126	" ulrichi Nicholson			*				
127	Batostoma erraticum Ulrich		*			*		
128	" implicatum Nicholson		*	*				
129	" jamesi Nicholson		*	*				
130	" nanum Ulrich			*				
131	" n. sp.				*			
132	" variabile Ulrich						*	*
133	Callopora dalei Ed. and Haime				*			
134	" expatiata Ulrich							*
135	" nodulosa Nich.			*				
136	" sigillaroidea Nich.		*	*				
137	" subplana Ulrich				*			
138	" ramosa d'Orb					*		
139	" rugosa Ed. and Haime					*		
140	Calloporella harrisi Ulrich						*	
141	" ? lens Whitfield						*	
142	Aspidopora areolata Ulrich		*					
143	" calycula Nich.		*					
144	" newberryi Nich.		*	*				
145	Constellaria florida Ulrich				*			
146	" fischeri Ulrich				*			
147	" limitaris Ulrich						*	
148	" polystomella Nich.						*	*
149	Batostomella gracilis Nich.					*		
150	" meeki James						*	
151	" simulatrix Ulrich						*	*
152	Bythopora arctipora Nich.		*	*				
153	Bythopora delicatula Nich.						*	
154	" fruticosa M. and D.				*			
155	Amplexopora cingulata Ulrich				*			
156	" pustulosa Ulrich						*	
157	" septosa Ulrich		*	*	*			
158	" robusta Ulrich					*		
159	**Atactopora** hirsuta Ulrich		*	*				
160	" maculata Ulrich			*	*			
161	**Leptotrypa** clavis Ulrich			*				
162	" cortex Ulrich			*				
163	" calceola M. and D.					*		
164	" clavacoidea Nich.					*		
165	" discoidea Nich.				*		?*	
166	" minima Ulrich					*		
167	" ornata Ulrich					*		
168	Monotrypella quadrata Rominger						*	*
169	" quadrangularis Whitfield							*
170	" subquadrata Ulrich						*	*
171	" aequalis Ulrich		*	*				
172	" briareus Nich.		*					
173	Monotrypa filiasa d'Orb				*	*		
174	" irregularis Ulrich				*	*		
175	" petasiformis Nich.		*	*				
176	" rectimuralis Ulrich				*	*		
177	" subglobosa Ulrich		*	*				
178	Discotrypa elegans Ulrich				*			
179	Ceramoporella distincta Ulrich		*	*		*		
180	" ohioensis Nich.		*	*	*			
181	Diamesopora communis Ulrich		*	*				
182	" vaupeli Ulrich			*				
183	Crepipora impressa Ulrich				*			
184	" simulans Ulrich				*	*		?*

		L. B.	XI a	XI b	XII a	XII b	XIII	XIV
185	Crepipora solida Ulrich			*				
186	" venusta Ulrich		*					
187	Cheiloporella flabellata Ulrich					*		
188	Spatiopora aspera Ulrich					*	*	
189	" lineata Ulrich					*		
190	" maculosa Ulrich		*	*	*	*	*	
191	" montifera Ulrich						*	
192	" tuberculata Ed. and Haime						*	
193	Dicranopora emacerata Nich.						?*	*
194	" fragilis Billings				*			*
195	" internodia Miller				*			
196	Pachydictya fenestelliformis Nich.						?*	*
197	Ptilodictya falciformis Nich.				*			
198	" hilli James				*			
199	" maculata Ulrich				*			
200	" magnifica Miller							*
201	" pavonia d'Orb				*			
202	" ponderosa Ulrich		*					
203	" variabilis Ulrich							*
204	Graptodictya perelegans Ulrich						*	
205	Arthropora sp	*	*	*				
206	" "				*			
207	" shafferi Meek					*		
208	" sp.						*	
209	Stictoporella interstincta Ulrich		*	*				
210	Fenestella oxfordensis Ulrich							*
211	Phylloporina clathrata M. and D.				*			
212	" variolata Ulrich			*	*			
213	Arthrostylus curtus Ulrich				*			
214	" tenuis Ulrich		*	*				
215	Paleschara beani James						*	
216	Orthis bellula James				*			
217	" ella Hall				*			
218	" emacerata Hall			*				
219	" meeki Miller						*	
220	" fissicosta Hall				*			
221	" insculpta Hall						*	
222	" jamesi Hall					*		
223	" multisecta James			*				
224	" " var. cyclus James			*				
225	" occidentalis Hall						*	*
226	" sinuata Hall				*	*	*	*
227	" plicatella Hall				*			
228	" retrorsa Salter						*	
229	" subquadrata Hall						*	*
230	" sectostriata Ulrich				*			
231	" scovillei Miller						*	
232	Platystrophia crassa James				*			
233	" acutilirata James							*
234	" laticostata James					*	*	
235	" lynx Von Buch					*		
236	" " small form				*			
237	Rhynchonella capax Conrad						*	*
238	" dentata Hall							*
239	" perlamellosa Whitfield						*	
240	" fringilla Billings					*		
241	Zygospira cincinnatiensis James				*			
242	" concentrica Ulrich				*			
243	" kentuckyensis James						*	
244	" modesta Say	*	*	*	*	*	*	*
245	[1]Glassia Schuchert and Ulrich						*	

[1] This name is proposed for the shell figured and described by Meek in vol. i, Ohio Pal., p. 127, pl. xi, figs. *a-1d*, under the name *Zygospira Headi* Billings (sp.). Recent investigations of excellent material, belonging to Mr. Charles Schuchert's extensive collection of palaeozoic brachiopoda, show that our shell is distinct from the Canadian form, and that it possesses internal spires arranged precisely as in Davidson's new genus

		L. B.	XI		XII		XIII	XIV
			a	b	a	b		
246	Strophomena alternata Conrad	*	*	*	*	*	*	*
247	" fracta Meek				*			
248	" rhomboidalis Wilckens						*	*
249	" gibbosa James		*					
250	" squamula James			*	*			
251	" nasuta Conrad					*		
252	" ponderosa Hall					*		
253	Streptorhynchus hallianus Miller			*				
254	" neglectus James						*	
255	" nutans James (Meek)						*	
256	" planoconvexus Hall				*			
257	" sinuatus Emmons				*			
258	" subtentus Conrad						*	
259	" sulcatus Verneuil						*	*
260	" vetustus James						*	
261	" thick form (?filitextus)						*	*
262	Leptaena plicatella Ulrich		*					
263	" sericea	*	*	*	*	*	*	*
264	" " var. aspera James			*				
265	Crania dyeri Miller			*				
266	" laelia					*	*	*
267	" scabiosa Hall	*	*	*	*	*	*	*
268	" socialis Ulrich			*				
269	Schizocrania filosa Hall	*	*	*	*	*		
270	Pholidops cincinnatiensis Hall		*	*	*	*		
271	Discina sublamellosa Ulrich			*				
272	" tenuistriata Ulrich			*				
273	Trematis punctostriata Hall			*				
274	" millipunctata Hall	?*	*	*	*	*		
275	" dyeri Miller				*			
276	Lingula cobourgensis Billings	*	*	*				
277	" daphne Billings	*			*			
278	" norwoodi James		*					
279	" quadrata Eichwald	*	*					
280	" riciniformis Hall	*	*					
281	" n. sp.	*	*					
282	" n. sp.			*				
283	" n. sp.		*					
284	Lingulella cincinnatiensis H. and W.				*			
285	Leptobolus insignis Hall		*					
286	" lepis Hall		*					
287	Fusispira subfusiformis Hall		*					
288	" terebriformis	*	*					
289	Bellerophon bilobatus Sowerby	*	*	*	*	*	*	*
290	" granistriatus Ulrich			*				
291	" nautiloides Ulrich						*	
292	" planodorsatus Ulrich			*				
293	Bucania expansa Hall							*
294	" ? costata James					*		
295	Cyrtolites carinatus Miller		*	*				
296	Cyrtolites dyeri Hall						*	
297	" elegans Miller					*		
298	" magnus Miller						*	
299	" nitidulus Ulrich		*					
300	" ornatus Conrad	*	*	*	*	*		
301	Microceras inornatum Hall	*	*	*	*	*	*	*
302	" minutissimum Ulrich		*	*	*	*		
303	Pleurotomaria ohioensis Hall		*	*				
304	" subconica Hall	*			*			
305	" subtilistriata Hall	*		*				
306	" trophidophora Meek			*				
307	Murchisonia augustina Billings				*	*		
308	" bowdeni Safford				*	*	*	
309	" gracilis Hall		*	*				

Glassia. Some of the specimens show further that the radiating striæ which usually mark the surface are often very obscure and in rare cases entirely absent. Such smooth examples were collected near Versailles, Ind.

		L. B.	XI a	XI b	XII a	XII b	XIII	XIV
310	" milleri Hall	*	*	*	*	*		
311	" multigruma Miller						*	
312	" perangulata Hall	*	?*					
313	Helicotoma helena Billings				*			
314	Trochonema ambigua Hall	*		*				
315	Cyclora depressa Ulrich	?*	*	*	*	*		
316	" hoffmani Miller			*				
317	" minuta Hall	*	*	*	*	*	*	*
318	" parvula Hall	*	*	*	*	*	*	*
319	Holopea obliqua? Hall	*			*			
320	" paludina formis Hall	*			*			
321	Cyclonema bilix Conrad? °				*			
322	" cincinnatiensis Miller		*					
323	" conicum Miller						*	
324	" fluctuatum James						*	
325	" transversum Ulrich				*			
326	" pyramidatum James				*	*	*	
327	" n sp.					*		
328	Metoptoma fissicosta Ulrich							*
329	" n. sp.							*
330	Conularia formosa M. and D.				*			*
331	" trentonensis Hall	*	*	*				
332	Hyolithes americanus Billings	*	*	*	*	*	*	*
333	Orthoceras amplicameratum Hall	*	*	*			?*	
334	" dyeri Miller				*			
335	" fosteri Miller						*	
336	" crebriseptum Hall				*	*		
337	" transversum Miller		*	*				
338	Endoceras proteiforme Hall	*	*	*	*	*	*	
339	Gomphoceras eos H. and W							*
340	" cincinnatienels Miller					*		
341	Trocholites ammonius Conrad	*	*					
342	Trochoceras baeri M. and W							*
343	Cyrtoceras conoidale Wetherby				*			
344	" lysander Billings						*	*
345	" valandinghami Miller				*			
346	Ambonichia carinata Goldfuss			*	*			
347	" casei M. and W							*
348	" intermedia M. and W	*	*	*				
349	" ? jamesi Meek					*		
350	" robusta Miller						*	*
351	" n. sp		*					
352	Anomalodonta alata Meek					*	*	
353	" gigantea Miller						*	*
354	Tellinomya alta M. and W	*	*					
355	" hilli Miller							*
356	" obligua Hall	*	*	*	*	*	*	*
357	" pectunculoides Hall			*	*			
358	Lyrodesma cincinnatiensis Hall			*				
359	" postriatum Emmons	*	*	*				
360	" planum Conrad		*					
361	Lyrodesma major Ulrich					*	*	
362	Cycloconcha mediocardinalis Miller				*			
363	" (Anodontopsis) milleri Meek						*	
364	Cypricardites hainesi Miller							*
365	" guadrangularis Whitfield						*	
366	" ?sterlingensis M. and W						*	*
367	Cleidophorus ellipticus Ulrich			*				
368	" fabulus Hall		*	*	*	*	*	*
469	" planulatus Conrad		*	*				
370	Cuneamya curta Whitfield						*	
371	" elliptica Miller					*		
372	" miamiensis H. and W						*	
373	" neglecta Meek						*	

° The genus *Cyclonema* is represented by numerous species in the Cincinnati rocks which are usually thrown together under Conrad's name *C. bilix*. The form here indicated by the name is figured by Meek in vol. 1 of the Ohio Pal., pl. 13, figs. *5a-5d*.

		L. B.	XI a	XI b	XII a	XII b	XIII	XIV
374	" scapha H. and W.						*	
375	Pterinea beililineata Billings						*	
376	" demissa Conrad.					*	*	*
377	" insueta Conrad		*					
378	" prolifica Billlings				*	*		
379	" mucronata Ulrich		*	*				
380	Anodontopsis ?unionoides Meek				*			
381	Modiolopsis ariculoides ?Hall		*					
382	" ?cancellata Walcott		*					
383	" cincinnatiensis H. and W.		*					
384	" concentrica H. and W.						*	
385	" ?curta Hall		*					
386	" faba Hall		*	*				
387	" pholadiformis H. and W.						*	
388	" modiolaris Conrad		*	*	*	*	*	*
389	" nasuta Conrad	*			*			
390	" rectiformis Worthen	*	*					
391	" terminalis Hall				*			
392	" truncata Hall				*	*		
393	" versaillensis Miller						*	
394	Orthodesma curvatum H. and W.						*	
395	" ?subovale Ulrich					*		
396	" rectum H. and W.					*	*	
397	Protoscolex covingtonensis Ulrich			*				
398	" ornatus Ulrich			*				
399	" ?simplex Ulrich			*				
400	Eotrophonia setigera Ulrich			*				
401	Arabellites lunatus Hinde			*	*	*	*	
402	" cristatus Hinde				*		*	
403	" cervicornis Hinde				*	*	*	
404	" spicatus Hinde				*		*	
405	Lambriconerites falciformis Hinde			*	*		*	
406	" obliquus Eichwald			*	*	*	*	
407	Conchicolites flexuosus Hall	*	*	*	*	*	*	*
408	" corrugatus Nich		*	*	*			
409	Serpulites dissolutus Billings			*	?*			
410	Tentaculites? sterlingensis? M. and W			*	*	*	*	
411	" oswegoensis M. and W.							*
412	Acidaspis crassota Locke		*	*				
413	" o'nealli Miller						*	
414	Ceraurus icarus Billings						*	
415	" pleurexanthemus Green	*	*	*	*	*	*	*
416	Triarthrus becki Green		*					
417	Calymene callicephala Green	*	*	*	*	*	*	*
418	Proetus parviusculus Hall				*			
419	Dalmanites callicephalus Hall	*	*	*	*			
420	" breviceps Hall						*	
421	Lichas trentonensis? Conrad	?*				*		
422	Trinucleus bellulus Ulrich			*				
423	" concentricus Eaton	*	*	*				
424	Asaphus gigas DeKay	*	*	*	*	*	*	?*
425	" megistos Locke	*	*	*	*	*	*	?*
426	Beyrichia chambersi Miller		*	*	*	*	*	
427	" ciliata Emmons			*	*	*	*	
428	" occulifera Hall					*		
429	" persulcata Ulrich			*				
430	" regularis Emmons						*	
431	" richardsoni Miller						*	
432	" ? striatomarginata Miller							*
433	Primitia byrnesi Ulrich		*					
434	" bivertex Ulrich		*					
435	" cincinnatiensis Miller						*	*
436	" crepiformis Ulrich			*				
437	Leperditia caecigena Miller							*
438	" radiata Ulrich		*					
439	Isochilina sp							*
440	Cytheropsis cylindrica Hall		*	*	*	*	*	*
441	" unicornis Ulrich		*					
442	Cythere? cincinnatiensis Meek						*	
443	" irregularis Miller						*	
444	Anomaloides reticulatus Ulrich					*		

		L. B.	XI a	XI b	XII a	XII b	XIII	XIV
445	Lepidolites dickhauti Ulrich	......	......	*				
446	" elongatus Ulrich	......	......	*				
447	Plumulites? jamesi H. and W	......	*	*	*	*	*	*
448	Pasceolus globosus Billings	......	......	......	......	......	......	......
449	Depranodus, two undescribed species	......	*	......	*	*		

(To be continued.)

SINGULAR SUBTERRANEAN COMMOTION NEAR AKRON, OHIO.

BY E. W. CLAYPOLE.

The hamlet of Sandy Hill about four miles south of Akron, O., was somewhat violently shaken during the night of February 9th. Several residents were awakened by a loud explosion which shook the houses as if an earthquake had occured. Plaster fell from the ceilings and the walls quivered. People sprang from their beds and rushed out to find the cause of the disturbance. Few in the immediate neighborhood slept any more that night. The district over which the shock was severe was not extensive and is thinly inhabited, but several houses stand close to the focus, and consequently felt its full force. At Mr. Snyder's several fissures in the ground were to be seen extending across the road. At Mr. Thornton's the family were awakened by the noise but the house did not sway. Mr. Shwartz who has lived all his life on the spot likened the noise to the report of a cannon. That this is not an exaggeration may be inferred from the fact that the explosion was heard by two persons in the house of Mr. John R. Buchtel, in Akron, more than five miles distant in a straight line, and that the register grating was heard to shake. The shock was double, the first happening about 9 o'clock on Thursday evening and the second between two and three o'clock on Friday morning.

This is not the only event of the kind that has occurred at Sandy Hill. In 1882 and 1883 similar explosions took place, an account of which the writer received from the lips of residents when visiting the spot in the summer of 1887. On that occasion the cracks in the ground radiated from a centre in a

field. Some of them extended for a distance of 200 or 300 feet from the focus. The largest was described as resembling the furrow left by a plough with the sod thrown back. It passed under Mr. Thornton's house and reached his barn, about 100 feet distant, where it ended. Some of the houses—especially Mr. Porter's—still show the cracks in the walls and ceiling made at that time. The noise, judging from the account, was as loud as that made by the recent explosion.

Another similar case was reported to the writer by Mr. Thornton. It happened when he was a boy or about twenty-five years ago, but his memory could not supply any details. Nor was the writer able to ascertain the exact date of the explosion of 1882 and 1883.

Sandy Hill lies near the North bank of the Tuscarawas river, and at an elevation of probably a hundred feet above that stream. It is in the region of the terminal glacial moraine which extends for several miles north and south of it. The preglacial valley now occupied by the Tuscarawas is here deeply buried with drift, which, judging from the tokens on the surface, cannot be less than one hundred feet deep. There is consequently no rock very near the surface.

Of course this phenomenon, though singular, is not of the nature of a true earthquake. Its limited extent and purely local violence exclude it from that category. It more resembles an explosion of gas, and to this cause it has been generally attributed. During the summer of 1887, acting on this belief, Mr. W. Buckmaster of Akron leased several farms with the intention of boring for gas, and at his request the writer then visited the ground and made a report upon it in which, notwithstanding the evident violence of the action, he hesitated to recommend drilling. Prof. M. C. Read of Hudson, O., also examined the spot at the request of Mr. Buckmaster and made another report. The two were in close agreement in all important points. No attempt has yet been made to drill for gas, the result of several holes sunk in 1887 failing to justify the hope that had been locally excited by reports from other places. Out of four wells near Akron only one yields a supply of any value, and that one does not probably give more than 50,000 feet a day.

The true explanation appears to be that there is a small sup-

ply of natural gas accumalating underground at this point. In ordinary times it leaks away into the air unnoticed. But in winter when the ground is frozen and its escape is prevented, it accumulates beneath the crust until its pressure rises high enough to burst it with explosive violence. In this way the cracks in the ground, the shock and the loud noise may be fully accounted for. In considering this explanation it must be borne in mind that gas wells of very moderate yield will, when closed, develop an enormous pressure which, however, rapidly subsides on opening the mouth of the bore-hole. There is also the possibility that the gas does not come from the black shale—the usual source of Ohio gas—but from some local bed of vegetable matter contained in the thick drift of the Tuscarawas valley. Lying also at a distance of several miles from any place where the product could be used the heavy cost of piping must be encountered. These and other similar considerations render it doubtful if commercial success would attend any efforts to win gas. Yet geologically it would be very interesting to find out the exact conditions which lead to results so singular, and which have seldom if ever been reported elsewhere so far as the writer is aware.

EDITORIAL COMMENT.

PROF. JUDD ON THE LAVAS OF KRAKATOA.

In the London Geological Magazine for January 1888 Prof. J. W. Judd discusses the lavas of Krakatoa and compares them with those of Santorin in the Mediterranean sea, of Buffalo peaks, Col. and of the Cheviot hills in the north of England. All these consist, he states, of a porphyritic mass composed of a colloidal glassy base with crystals of felspar, enstatite, augite and magnetite. The chemical composition of the base and that of the crystals differ but slightly in all these lavas but their relative quantity varies from 90 per cent to 10 per cent. The nature of the rock as a whole therefore varies from a distinctly acid to a distinctly basic magma.

Prof. Judd next shows that all the lavas from Krakatoa

though agreeing in chemical composition present three distinct mineralogical types due to the different conditions of the glassy matrix. In the first devitrification has proceeded so far that the matrix is a stony dull reddish-gray mass crowded with microlites. In the second the matrix consists of black pitchstone and in the third it is an almost perfect amber-brown glass, or obsidian. The last of these on treatment before the blowpipe melts and swells up, evidently containing some volatile ingredient, the presence of which has changed most of the obsidian into pumice in the field. Prof. Judd next discusses the effect of the presence of water in lowering the fusing point of rocks and quotes from the late F. Guthrie a table showing how the fusing point of nitre was reduced from 320° C. to 97° C. by the addition of about 40 per cent of water. A legitimate inference from this experiment seems to be that aqcuous and igneous fusion merge into one another so that no line can be drawn between them.

Prof. Judd concludes with the remark that if to a mass of nitre lying in the crust of the earth at a temperature of 290° C. water should find access, its fusion would certainly follow, and that the same result might be looked for in the case of a mass of mixed silicates without any rise of temperature.

PREGLACIAL MAN.

The controversy over the so called preglacial man between Dr. Hicks on the one side and Prof. Hughes on the other, which has been going on for some months, is continued in the same number. For the clear comprehension of the argument Dr. Hicks should define exactly what he means by the term preglacial? It may imply "altogether anterior to the ice-age," "anterior to the last ice-age," or "anterior to the last stage of the last ice-age," and it is impossible to form an opinion from the published evidence, without knowing in which sense the term is used. Prof. Hughes appears to be unnecessarily sceptical on the subject of preglacial man (using the term in the second of the senses given above) or interglacial man as he should be called. There is little doubt that we shall soon be justified in recognizing such a stage in human history as a reality.

judging from the evidence slowly coming to light in different parts of the world.

So far as it is possible to decide from the printed testimony Dr. Hicks has made out a good case in the Cae-Gwyn cave for inter-glacial man but it does not appear to us that his evidence proves human existence in pre-glacial time.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geology and mining industry of Leadville, Colorado, with atlas. By SAMUEL FRANKLIN EMMONS. (Monographs of the United States geological survey; volume xii). The work which is here reported on was begun in 1879, under the direction of Clarence King, the first director of the United States geological survey. The letter of transmittal is dated Oct. 1, 1885, although the report was essentially completed four years earlier, when a full "abstract" of it was published in the second annual report of the director of the survey. The volume is very largely from the hand of Mr. Emmons, including the general and descriptive geo logy, and the discussion of geological phenomena. The entire description of the mining industry is also by Mr. Emmons. The petrography is by Whitman Cross, the chemistry by W. F. Hillebrand and the metallurgy by Anthony Guyard. The atlas was prepared under the direction of A. D. Wilson, chief topographer, and the paleontological determinations were made by Mr. R. P. Whitfield. It is useless to attempt here an adequate account of this admirable volume and the atlas which accompanies it. It compares most favorably with other volumes of the series which have been issued by the survey. The author gives the following brief outline of results of the study.

The mosquito Range, the study of whose geological structure formed a necessary basis for that of the ore deposits of the Leadville region, is the western boundary of the South Park, and has thus been considered from a topographical standpoint to form part of the Park Range. Geology shows, however, that in Paleozoic times the boundaries of the depressions now known as the parks were formed by the Archean land masses of the Colorado Range on the east and of the Wasatch and its continuation to the north, the Park Range on the west, and that the uplift of the Mosquito Range did not occur until the close of the Cretaceous.

Prior to this uplift the various porphyry bodies, which now form a prominent feature among the rock formations of the region, were intruded into the sedimentary beds deposited during Paleozoic and Mesozoic times, spreading out between the beds and sometimes crossing them, but being most uniformly distributed at the top of the Lower Carbon-

iferous or Blue Limestone. It was in this limestone that the greater part of the ores were deposited, and the original deposition must have taken place after the intrusion of the porphyry and before the uplift of the range.

In the uplift of the range both eruptive sheets and sedimentary beds, with the included ore deposits, were plicated and faulted, and by subsequent erosion an immense thickness of rocks has been carried away laying bare the very lowest rocks in the conformable series; the outcrops are, however, frequently buried beneath what is locally called "wash," a detrital formation of glacial origin. In the Leadville region, owing to the reduplication caused by faulting, a series of outcrops of easterly dipping beds of the Blue Limestone are exposed beneath the wash, of which all are metalliferous and a considerable proportion carry pay ore.

The principal ore deposits of Leadville occur, as above indicated, in the Blue Limestone and at or near its contact with the overlying bodies of porphyry. The ores consist mainly of carbonate of lead, chloride of silver and argentiferous galena, in a gangue of silica and clay, with oxides of iron and manganese and some barite. These materials are mainly of secondary origin, and result from the alteration by surface waters of metallic sulphides.

The study of these deposits has shown: 1, that they were originally deposited as sulphides, and probably as a mixture, in varying proportions, of galena, pyrite, and blende; 2, that they were deposited from aqueous solutions: 3, that the process of deposition was a metasomatic interchange between the materials brought in by the solutions and those forming the country rocks, consequently that they do not fill pre-existing cavities; 4, that the ore currents from which they were deposited did not come directly from below, but were more probably descending currents; and 5, that these currents probably derived the material of which the ore deposits are formed mainly from the porphyry bodies which occur at horizons above the Blue Limestone.

Inasmuch as the ore currents did not come directly from below, it is not advisable to search for ore below the Blue Limestone horizon. This horizon, however, should be thoroughly prospected, and the maps and sections show its probable position in the as yet unexplored areas; the explorations, moreover, should not be confined to the upper surface of this limestone, but carried into its mass wherever there are indications of ore, and especially along the contact of tranverse bodies of gray porphyry. The probabilities are that very considerable bodies of ore remain as yet undiscovered, and the most promising areas for prospecting are indicated. It is also probable that as the distance from the surface increases the ores will be found less altered, and that they will therefore be less easily reduced by the smelting processes now employed.

Note on fossil wood and other plant remains, from the Cretaceous and Laramie formations of the western territories of Canada. By SIR WILLIAM

DAWSON. (From the Transactions of the Royal Society of Canada; read May, 1887).

About sixty distinct trees, most of them found *in situ*, from the Belly River, Fort Pierre and Laramie groups, have been examined in thin slices by the author. He forbears to add any specific names, but remarks that they probably have all been described before from specimens of their leaves and fruit. He refers them all to their generic names only.

In the Belly River and Fort Pierre series he identifies *Sequoia*, the "big tree" of California, and the "redwood" of California; *Taxites*, yew; *Ginkgo*, similar to the Chinese ginkgo; *Thuja*, arbor vitæ; a *Pinus* or *Abies*(?), pine or spruce; *Betula*, *Populus*, *Carya*, *Ulmus*, *Platanus*(?).

From the Laramie he identifies the same two types of *Sequoia*, the same *Taxites*, the same *Ginkgo*, *Thuja*, and *Pinus* (?). He also here finds *Juglans*, *Betula*, *Populus*, *Acer*.

Other plants are as follows, from the Laramie, *Onoclea sensibilis* Lin, *Sequoia couttsiæ* Heer, *Podocarpites tyrrellii* n. sp., *Populus arctica* Heer, and *P. genetrix* Newb., and *nervosa*, *Salix laramiana* Dn., *Carya antiquorum* Newb., *Nelumbium saskatchuense* n. sp., *Trapa borealis* Heer, *Viburnum saskatchuense* n. sp., *Vibernum asperum* Newb., and a *Sapindus* which is near *S. obtusifolia* Lesq.

The author remarks in conclusion:

An important geological consequence arising from this is, that the period of warm climate, which enabled a temperate flora to exist in Greenland, was that of the later Cretaceous and early Eocene, rather than, as usually stated, the Miocene. It is also a question admitting of discussion whether the Eocene species of latitudes so different as those of Greenland, Mackenzie river, N. W. Canada and the western states, were strictly contemporaneous, or successive within a long geological peorid in which climatal changes were gradually proceeding. The latter statement must apply at least to the beginning and close of the period; but the plants themselves have something to say in favour of contemporaneity. The flora of the Laramie is not a tropical but a temperate flora, showing no doubt that a much more equable climate prevailed in the more northern parts of America than at present. But this equability of climate implies the possibility of a great geographical range on the part of plants. Thus, it is quite possible, and indeed highly probable that, in the Laramie age, a somewhat uniform flora extended from the arctic seas through the great central plateau of America, far to the south, and in like manner along the western coast of Europe. It is also to be observed that, as Gardener points out, there are some differences indicating a diversity of climate between Greenland and England, and even between Scotland and Ireland and South of England, and we have similar differences, though not strongly marked, between the Laramie of northern Canada and that of the United States. When all our beds of this age, from the Arctic sea to the 49th parallel, have been ransacked for plants, and when the palæobotanists of the United States shall have succeeded in completely unravelling the confusion which now exists between their Laramie and the Middle Tertiary, the geologist of the future will be able to restore with much certainty the distribution of the vast forests which, in the early Eocene, covered the now bare plains of interior America. Further, since the break which, in western Europe, separates the flora of the Cretaceous from that of the Eocene, does not exist in America, it will then be possible to trace the succession of plants all the way from

the Mesozoic flora of the Queen Charlotte islands and the Kootanie series, described in previous papers in these Transactions, up to the close of the Eocene, and to determine, for America at least, the manner and conditions under which the angiospermous flora of the later Cretaceous succeeded to the pines and cycads which characterzied the beginning of the Cretaceous period.

NEW PUBLICATIONS.

1. State and Government reports.

Preliminary description of the peridotytes, gabbros, diabases and andesytes of Minnesota. 8vo., pp. 158, 12 plates. M. E. Wadsworth. Bulletin No. 2, of the *Minnesota geological survey, Minneapolis.*

2. Proceedings of scientific societies.

The Journal of the Cincinnati Society of Natural History, pp. 151-236. One plate of Monticuliporoids. *Cincinnati.*

3. Papers in scientific journals.

In the February number of the American Journal of Science. On a new petrographical microscope of American manufacture. *G. H. Williams.* A new Ammonite which throws additional light upon the geological position of the Alpine Rhætic. *W. B. Clark.* Three formations of the middle Atlantic slope. *W. J. McGee.* With one plate. Are there deep-sea Medusæ? *J. W. Fewkes.*

4. Excerpts and individual publications.

On the monticuliporoid corals of the Cincinnati group, with a critical revision of the species. By U. P. and Joseph F. James. Part II. *Journal ot the Cincinnati Society of Natural History*, January, 1888.

Notes on the precise geological horizon of *Siphonotreta scotica* Davidson. By Henry M. Ami. *Ottawa Naturalist*, December, 1887.

Notes on some diabase dykes of the Rainy lake region. By Andrew C. Lawson. *Proceedings of the Canadiau Institute*, 1887.

Supplement I. To the bibliography of the foraminifera, recent and fossil, including Eozoon and Receptaculites. (Printed in the Fourteenth Annual Report of the Geological and Natural History Survey of Minnesota, pp. 167-311, 1885.) By Anthony Woodward. *Journal of the New York Microscopical Society*, January, 1888.

5. Foreign publications.

Memorias de la Sociedad Cientifica "Antonio Alzate." Tome 1, Cuadernos numeros 6 y 7; Diciembre de 1887 y Ennero de 1888. *Mexico.*

Ueber Gebirgsruppierung. Vortrag, gehalten auf dem *siebenten deutschen Geographentag zu Karlsruhe;* von Dr. August Böhm, *Berlin.*

PERSONAL AND SCIENTIFIC NEWS.

HAMLINE UNIVERSITY AT HAMLINE MINNESOTA has recently erected and occupied a "Science Hall." The building is of red brick with brown stone trimmings and consists of a main portion in front about fifty feet by thirty, three stories high, and a rear extension one story high. The main or front building is divided into two parts by a central hall and each of these divided furnishes four large rooms on the first and second floors. The east side of the second floor and the entire third floor are devoted to the department of biology and geology. The rooms thus furnished are a large lecture room, a large well-lighted laboratory, a small preparation room on the second floor, and a large museum room on the third floor for present occupation, with additional space on the west half of the second floor when required. The extension, one story high, completely shut off from the main part by solid brick walls and sheet iron doors, is entirely given up to the departments of physics and chemistry. It is divided into lecture room, preparation room and private laboratory, apparatus room, general laboratory and balance room. Beneath the first floor, under the extension, there is a high basement finished in a number of small rooms for the use of the physical department as required; and under the front part a large gymnasium.

PROF. J. W. SPENCER, LATE OF THE UNIVERSITY OF MISSOURI, is engaged in an independent investigation of the beaches and basins of the great lakes. His address is Ann Arbor, Mich.

DR. C. T. LINDLEY, DAVENPORT, IOWA, whose valuable cabinet of natural history was destroyed by fire Nov. 9th, last, is trying to renew it, and solicits duplicates from such geologists and naturalists as have them to spare. The great collection was deposited in the state orphan's home at Davenport, and the building was fired by a stroke of lightening.

PROF. ALLEYNE NICHOLSON DESCRIBES in the London Geol. Mag. certain indistinct forms not at present referable to any geological group, but contributing largely to the building up of some of the palæozoic limestones. They belong to the genera *Mitcheldeania* of Wethered *Solenopora* of Dybowski, and *Girvanella* of Etheridge and Salter. To each of the first and third a single new species is allotted, and under the second are described two. But as the figures are necessay for a full comprehension of the paper, the reader is referred for further detail to the original. Mr. T. M. Reade also calls attention to the permanent elongation of terra cotta, under changes of temperature. This elongation has the effect he says of raising a coping into a long, low anticline if the ends are secured, or of thrusting out and cracking the piers, if their stability is unequal to the pressure. He suggests its practical bearing on the subject of mountain building.

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NOTES ON SOME DIABASE DYKES OF THE RAINY LAKE REGION.

BY ANDREW C. LAWSON, M. A.,

Geologist to the Geological Survey of Canada.

The most recent of the crystalline rocks of the Rainy lake region are comprised in a series of strong dykes of comparatively fresh diabase which are observed to cut, at different localities, the various members of the Archæan complex of formations. These dykes are not infrequent throughout the country lying between the eastern confines of the first prairie steppe, which forms the basin of the Red river of the North, and the western border of the area of Animikie and later formations of the lake Superior basin. Their occurence and some of their characters are briefly referred to in my report on the Lake of the Woods region.[1] As there observed, the occurence of these dykes cutting the older folded rocks, which in their eastward geographical continuation, pass under the flat-lying Animikie and Keweenawan formations, is suggestive of their possible connection with the bedded traps that form so large a part of the two latter geological series. With the question of the possible identity of character and age of these dykes with the traps of the Animikie or Keweenawan, or of both, is associated the equally interesting one of the extent of the earth's surface, over which, in early geological times, were in simultaneous operation, those particular volcanic forces which appear to have had their focus in the lake Superior basin.

The more notable field characters of these dykes are: their

[1] Geological and Natural History Survey of Canada; annual report, 1885, p. 41 CC., p. 47 CC.

common strike throughout the region from N. W. and S. E. to N. N. W and S. S. E.; the sharp, well defined nature of the gash or fissure which they fill, no matter what may be the character of the country rock; the absence of inclusions of the country rock, or of apophyses of the dyke running into it, except in very occasional instances; their generally uniform width under different conditions of occurrence in different localities, the limits being as a rule 60 and 150 feet; their continuity for one or several miles where exposures permit them to be traced; their passage from a very compact, aphanitic, black rock at the immediate contact with the dyke walls, by insensible gradations to a very coarse-grained, mottled, dark gray rock in the middle of the dyke; an occasionally observed peculiar pitting of the weathered surface, arranged in straight, more or less uniformly spaced lines transverse to the strike of the dyke; their prominent, steeply rounded, or domed, glaciated surfaces in contrast to the more gently inclined *roches moutonnees* of the schists and gneisses; their assumption of brownish tints on surfaces aerially weathered; (surfaces beneath high water mark of the lakes are generally quite fresh and black.)

These dykes have as yet received only a preliminary study, and it will require a much more extended examination of the country in which they occur and a much more elaborate investigation of their petrographical characters before a comprehensive statement of their geological relations can be formulated. A few notes regarding the microscopic features of these dykes, taken together with what has been said of their field occurrence, may however, be of interest, and will serve as a report of progress of what is being done in this line of investigation in the field west of lake Superior.[1]

One of the most characteristic of these dykes is one that traverses the coarse granitoid gneiss of the west arm of Jackfish lake, which lies to the north-west of Rainy lake. Its width is 135 feet and its contact with the country rock is well exposed as a sharp line. From a macroscopic examination the gneiss

[1] These rocks were studied microscopically in the laboratory of the Johns Hopkins University, Baltimore, under the guidance of Prof. G. H. Williams, for whose kind advice and assistance the writer desires to express his grateful acknowledgments.

does not appear to have been altered perceptibly towards the contact. Specimens for microscopic examination were taken from different parts of the dyke, viz., at 60 feet, 20 feet, and 6 feet from the contact, and at the contact. At 60 feet from the contact, the rock is a coarse-grained mottled gray rock in which dirty white feldspar and black pyroxene are the prominent constituents. Under the microscope it presents the characters of a coarse-grained, comparatively fresh diabase. Augite of a pale mauve tinted gray colour is abundant and often occurs in masses that fill the field of the microscope when low powers are used. Sometimes these plates of augite are individual crystals. For the most part however, they are not single individuals. When examined between crossed nicols the plate of augite is seen at once to be resolved into an intimately interlocking mosaic of irregularly shaped grains of diverse optical orientation. In ordinary light the boundaries between the different members of these "polysomatic"[1] masses of augite are traceable only with difficulty and uncertainty. There is no interstitial matter whatever, the different grains being as intimately associated as in the case of interpenetration twins of feldspar. That they are not twins is shown by the fact that there are often as many as half-a-dozen grains all of different orientation thus combined in the same mass. The cleavage, by its lack of continuity over the field, of course indicates a difference of orientation in different parts of it, but the cleavage traces are not strongly marked, and attention is only directed to the discordance of the cleavage after the polysomatic character of the mass has been rendered prominent by the analyzer of the microscope. This polysomatic structure of augite does not appear to be common. Rosenbusch does not mention it in his last comprehensive summary of the present state of petrographical knowledge.[2] The nearest approach to this structure that is at all well known is the polysomatic character of some chondri of olivine in certain meteorites such as are figured by Tschermak[3]

[1] Adapted from Tschermak's use of this word as applied to a similar structure in the olivine of certain meteorites.—V. Die Mikr. Beschaff. der Meteor. Stuttgart, 1885.

[2] Mikr. Phys. der Mineralien und Gesteine; Stuttgart, 1886.

[3] Die Mikr. Beschaff. der Meteor. Stuttgart, 1885, Taf. xv., Figs. 1 and 2.

and Wadsworth.[1] Olivine in a similar condition in terrestrial rocks has recently been described and figured by Rénard in specimens from Kerguelen island in the Indian ocean.[2] The polysomatic structure in augite is not so well known. Rénard notes that the augites of the feldspathic basalt of Heard island, Indian ocean, are grouped together at certain points,[3] and again in the same rocks in Marion island that the augite is characterized by a tendency to form groups of individuals having their vertical axes parallel.[4] Teall mentions "granular aggregates" of augite in the Hett and the High Green dykes in the north of England.[5] Some of these appear from the figures given to be aggregates of grains of augite not in close juxtaposition with an interstitial base, although that figured in plate XII, fig. 5, would seem to be a polysomatic augite, and if so is the only strictly parallel instance that I can find of this structure so common in this dyke and in others of the region.

The augite is generally altered to hornblende at its periphery and occasionally the latter mineral entirely replaces the former. The process of alteration does not appear to proceed along the almost or quite imperceptible lines of demarkation between the different individuals of the polysomatic augite, but extends from the periphery of the mass as a whole in towards its centre.

The plagioclase appears in two general forms, a rather stout or tabular form which is the larger and usually the more cloudy with decomposition products, and a small long lath-shaped feldspar which appears quite fresh and in which the polysynthetic lamellae are much more distinct than in the former.

Magnetite occurs in irregularly bounded masses or is disseminated, often quite thickly, through the augite as inclusions of dusty or finely granular aspect. Pyrite also occurs and is discernible macroscopically. Apatite is seen in occasionally color-

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[1] Lithological Studies, Mem. Mus. Comp. Zool. Harvard, vol. x. pl. 1.

[2] Notice sur la geologie de l' ile de Kerguelen, Bul. Mus. Roy. Hist. Nat. Belgique, tome iv. No. 4., p. 233, fig. 1, pl. v.

[3] Notice sur les roches de l' ile Heard. Bul. Mus. Roy. Hist. Nat. Belgique, 1886, 8 p. 260.

[4] Notice sur les roches de l' ile Marion. Ibid. p. 250.

[5] Petrographical Notes on some north of England Dykes, Q. J. G. S., 1884, 158. p. 229 and 242.

less hexagonal sections and in slender prisms with rounded terminations. Water-clear quartz, with inclusions of apatite microlites and liquid inclusions with dancing bubbles, forms a considerable proportion of the mineral constituents of the rock and is characterized by having a common orientation for isolated sections over a wide area of the microscopic field, as in the micropegmatite structure. A few colorless garnets are also present. The rock, such being its characters, may be classed as a uralitic quartz diabase.

At 20 feet from the contact the rock is very similar to that at 60 feet but is much less coarse in texture. It differs from the latter in mineralogical composition in that fact that there is present an abundance of white or colorless garnets, all perfectly isotropic. They have a well defined border indicative of a high index of refraction and a perceptibly rough surface. Their shape is for the most part rounded, or, when rectilinear outlines are observable, they are hexagonal sections of the rhombic dodecahedron. The larger grains have a curved parting which may be demarkation lines between different individuals. The treatment of the slide with hydrochloric acid cold or hot, leaves them unaffected. The occurrence of garnets in basic dykes is by no means unique. They are however regarded as a product of contact metamorphism within the dyke. Speaking of the "Iron District of Lake Superior," Wadsworth says, "Most of the "diorites" (uralitic diabases) here (at Republic Mt.) contain garnets, this mineral being found principally along the edge of the intrusion while the centre was nearly if not entirely free from it. The schist in like manner near the "diorite" frequently contains garnets, both rocks appearing to have mutually reacted upon each other."[1] The garnets in the Jack Fish lake dyke do not appear to be a product of contact metamorphism since they are found in the middle of the dyke and very much more abundantly at 20 feet from the contact than at 6 feet from it, or immediately at the contact, where their presence has not been detected. Beyond the abundance of garnets, the dyke at 20 feet has the same characters as at 60 feet. The polysomatic structure of the augite is pronounced.

[1] Notes on the Geology of the Iron and Copper Districts of Lake Superior. Bul. Mus. Comp. Zoöl. Harvard, 1880, pp. 45, 46, 47.

At 6 feet from the contact the rock is fine grained and the ophitic structure of typical diabase is much more characteristically developed than in the coarser grained parts of the dyke. In this part of the dyke there is first observed a differentiation of the rock into constituents of different periods of crystallization, the order being first plagioclase in more or less idiomorphic[1] lath-shaped individuals lying in all positions, then augite generally allotriomorphic,[1] sometimes hypidiomorphic[1] and finally a base or matrix of both these minerals in a very much more finely crystalline state together with magnetite. The structure of the base is rather obscure, the chloritic substance usually present in diabase rocks being more prominent here than in the coarser grained part of the dyke where it is almost or perhaps entirely wanting. Quartz is present but in smaller quantities than in the coarser grained portions of the dyke. The augite occurs both in simple individuals and in polysomatic masses. The uralitization of the augite, which is generally observable, is much more pronounced in the irregularly bounded polysomatic masses than in the simple allotriomorphic development of the same mineral. A few garnets are present as inclusions in the feldspar but were not identified with certainty. In this respect this portion of the dyke differs markedly from the more central portions examined. The most interesting constituent of this portion of the dyke remains, however, to be mentioned. It is the non-pleochroic colorless rhombic pyroxene enstatite; it occurs in idiomorphic development showing the characteristic obtuse domes in some of the sections. It shows regular cleavage parallel to ∞ P (110), upon which the angle of extinction is zero, and characteristic cross parting along which partial alteration of the mineral to bastite or serpentine is apparent. This enstatite is not abundant and plays the role of an accessory mineral. Its occurrence in a rock of well marked diabase structure is interesting. Rosenbusch remarks that it is present in only a few diabases which have a gabbro-like structure,[2] and Teall has recorded the occurrence of the allied rhombic pyroxene bronzite in the Whin-Sill of the north of England as an accessory.[3] En-

[1] Terms introduced by Rosenbusch. Cf. op. cit. p. 11.
[2] Mik. Phys. der Massigen Gesteine, 2nd Ed., 1886, p. 188.
[3] Q. J. G. S., 1884, p. 652.

statite also occurs in variety of the allied rock diabase porphyrite from Schaumberge, which has been described by Laspeyres and Streng under the name Palatinite. This enstatite was not observed in the coarser parts of the dyke but occurs, as will be noted, in the still finer grained diabase at the contact.

At the immediate contact the dyke assumes microscopically the characters of a very compact grayish black aphanitic rock in which can be occasionally detected minute glistening facets of porphyritic crystals. With low powers of the microscope the matrix is not resolvable but appears as a uniformly yellowish to greenish gray ground thickly dotted with grains of magnetite. * Under the higher powers this is seen to be made up, in addition to magnetite, of a fine felt-work of minute lath-shaped crystals of plagioclase imbedded in a hazy, somewhat yellowish green flocculent chlorite substance derived presumably from the alteration of the augite, since that mineral cannot with certainty be identified in the base. The porphyritic character of this part of the dyke is well marked, though the imbedded crystals are small. These are augite in small irregular polysomatic masses, with a hazy margin or fringe of greenish decomposition product, and long lath-shaped plagioclase and occasionally stouter broken fragments. Besides these there are porphyritic crystals of enstatite much more altered and less plentiful than at 6 feet from the contact. Neither quartz nor garnets are observable in the contact.

Considering then the dyke with reference to its variation in structure and mineral composition the points of interest to be noted are: The passage of the coarse grained central portions of the dyke to compact aphanitic rock at the contact; the absence of porphyritic structure in the middle of the dyke as contrasted with the well marked development of the same as the rock becomes finer grained towards the dyke walls; the absence of the characteristic chloritic substance of diabase in the centre of the dyke and its abundance towards the contact; the presence of quartz in greater quantity in the coarse grained middle portions than at the sides; the presence of garnets in the coarsest parts of the dyke, their abundance in the medium grained parts and their rarity or total absence in the neighborhood of the contact; the presence of the rhombic pyroxene enstatite in typical idio-

morphic porphyritic crystals in the fine grained parts near the contact and its absence in the coarser central parts; the diminution in size of the porphyritic crystals near the contact in co-extension with the increasing fineness of the ground mass; and finally the "polysomatic" structure common to the augite throughout the dyke.

Three quarters of a mile from the exposure where the specimens whose characters have just been given were collected, there occurs, on the opposite side of the bay in the line of the strike of the dyke, another exposure of the same dyke. On the islands of the bay which lie intermediate between these two localities the outcrop of the dyke is observable, so that there is no doubt of their both being exposures of the same dyke. The rock here was not studied in so great detail as at the last exposure. The specimens taken were of the same grade of coarseness as those taken at 20 feet from the contact on the north side of the bay. The feldspars are more decomposed and the twinning lamellæ often obscure, and the small quantity of quartz which is associated with them appears to be of secondary origin; whereas the origin of the quartz noted in the same dyke on the north side of the bay seemed much more problematic. In the latter case the common micropegmatitic character of the quartz and the occurrence in it of needles of apatite, which in no way differ from those in the feldspar, together with the not infrequent occurrence of one individual of apatite partially included in quartz and partially in adjacent feldspar, would argue for the primary character of the quartz. The augite in the dyke on the south side of the bay resembles that already described occurring both in simple individuals and in polysomatic masses. It is largely altered to uralite. Titanic iron with its alteration product leucoxene shows characteristic barred structure of the cleavage traces parallel to the planes of the rhombohedron. The leucoxene is frequently accompanied by a margin more or less extensive, of secondary brown mica. Apatite is present in comparative abundance. Chlorite occurs in vaguely defined masses and the garnets which, as before, are present, are associated with it.

On the south-east shore of Pipestone lake about a mile west of Stone-dam Portage occurs another of these dykes cutting

transversely schists which have a strike of N. E. to E. N. E. The specimen taken from the middle of the dyke has the characters of a uralitic quartz diabase. The feldspar as a rule is remarkably fresh and occurs in the usual lath-shaped twinned crystals of plagioclase. The crystals are commonly observed to be cracked transversely and the cracks filled with a brownish yellow material which shows aggregate polarization. The augite occurs more commonly in polysomatic masses than in simple individuals. The magnetite is often surrounded by rims of secondary brown mica. The quartz is apparently original and has numerous inclusions of an opaque granular character together with fluid inclusions with dancing bubbles, gas pores with black borders and glass inclusions oval and circular.

Fig. 1.

Section of diabase, from Pipestone lake dyke, showing large polysomatic grain of augite in three granules of diverse orientation *a b c*; *d* uralitic hornblende; *e* magnetite. x 28.

On the south shore of the North-west bay of Rainy lake, a similar dyke cuts both the biotite gneiss of the region and the red granite which is intrusive through it. It is a uralitic quartz diabase. The feldspar is in rather stout crystals in the coarser grained part of the dyke, though usually lath-shaped. It is much decomposed and is partially replaced by quartz and chlorite. The polysomatic character of the augite is not prominent but this may be due to the fact that it is about half altered to hornblende and to chlorite. The augite individuals are often twinned and the cleavage traces are unusually well defined. The magnetite shows a tendency to peripheral arrangement around the altered augite indicative of its secondary origin. Quartz is present which is probably original besides that which is clearly secondary. Apatite in long slender needles and leucoxene in irregular masses, are the accessory constituents.

In the same dyke, nearer the contact where the texture is fine

grained, the rock is much uralitized, traces of augite being observable only in cores of the compact green hornblende, which has almost entirely replaced it. Apatite appears more abundant, as do also the secondary quartz and chlorite. Garnet of a pale yellowish color occurs sparingly.

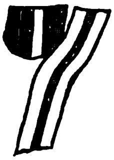

Fig. 2.

Plagioclase from diabase dyke, Northwest bay, Rainy l., showing effect of pressure of one crystal against another.

At the contact the dyke rock is a compact aphanitic base in which can be detected minute porphyritic crystals. Under the microscope the base is seen to be made up of minute lath-shaped crystals of fresh plagioclase, augite grains, magnetite and chlorite substance. The porphyritic crystals are lath-shaped feldspars occasionally broken and showing the lamellae in some instances bent, as the result of pressure of one individual against an angular part of another, and augite generally surrounded with an irregular border of secondary hornblende, which, in turn, has an outer girdle or wreath of granules of magnetite that have separated out in the process of uralitization as in fig. 3.

Fig 3.

Augite from diabase dyke, Northwest bay, Rainy L., showing marginal alteration to green compact hornblende with an encircling wreath of secondary magnetite.

In the south part of the Rainy lake and on the Rainy river a number of these dykes have been observed. One cuts the coarse granitoid gneiss of the river between Couchiching and Fort Frances on the south side of the river, and another crosses the river at the Manitou rapids. Neither of these has yet been examined microscopically. On the lake near the extremity of Gash point one of these dykes cuts the schists with a strike of N. W. and S. E. across the whole breadth of the point and traverses the islands on both sides of it. Here it is traceable on the point and on the islands for a distance of a mile. Three miles to the south east in the line of the strike of the dyke, a dyke occurs cutting the schists on the islands off the south shore of the lake which is probably a continuation of that of Gash point. From this point it is traceable for two miles across the islands to the main shore on the south side of Grassy narrows. Thus, this dyke has a length of at least six miles and has an extension to the north-west and south-east of the

points observed, for a distance that is probably very much greater. A specimen from the central part of this dyke, proved on examination to have the characters of a uralitic quartz diabase. The plagioclase occurs in long, rather stout, lath-shaped crystals, which are generally so cloudy as to obliterate the twinning in most cases. The augite occurs both in simple individuals and in polysomatic masses. It exhibits the usual marginal alteration to hornblende and there is besides a certain amount of chlorite. Original magnetite is frequently surrounded by a margin of secondary biotite. Micropegmatitic quartz is abundant. It is often intimately intergrown with the feldspar, and as the latter is much decomposed, would seem to replace it as a partial pseudomorph, but apatite needles of the same aspect as those which occur as inclusions in feldspar, augite, and quartz, are often seen to be inclosed partly in a feldspar and partly in a quartz grain. The primary origin of the quartz in spite of its micropegmatitic character, is however, not beyond doubt. It is to be noted that were the quartz original we should hardly expect to find it in such close association with the feldspar. The plagioclase of these rocks affords unmistakable evidence in its idiomorphic character of its having first crystallized from the magma. The augite crystallized next, enclosing the lath-shaped plagioclase; and the quartz, which would be the last to crystallize, we should expect to find separated from the plagioclase by the augite, *i. e.*, to fill in the interstices between the augite. Again although single apatites are often found extending from a quartz grain to a feldspar grain, a condition of things favoring the notion of a common primary origin of both the latter minerals, yet such a phenomenon is not incompatible with a secondary origin for the quartz, since the replacement of feldspar by quartz must necessarily be a slow operation and proceed particle by particle. Further, if the quartz were original we should hardly expect to find in it inclusions of crystals of the first generation like apatite, which would be liable to be enclosed for the most part in the earlier secretions like feldspar and augite,

Fig. 4.

Polysomatic grain of augite—Grassy narrows dyke, Rainy lake; *a* and *b* are twins—the other granules are of diverse optical orientation. x 28.

rather than in the residual silica of the magma. The non-existence, however, of quartz in some diabases which are very much decomposed, and its presence in fresh ones, militates against the theory of the secondary origin of the quartz in these rocks, so that the question of how much of the quartz is primary and how much secondary in an old diabase is a question that as yet does not appear susceptible of definite settlement.

About a mile to the west of this dyke where it crosses Grassy Narrows island is another nearly parallel dyke converging on the former at a small angle towards the south. The rock is a uralitic quartz diabase and in its coarser portions, near the middle, the texture is more granular than that of typical diabase. The plagioclase is cloudy with decomposition products and quartz is abundant. The augite is entirely replaced by compact green hornblende, the only indication of the augite that remains being the light colored character of the central portion of the hornblende and the abundance of magnetite granules that have separated out in the process of alteration. Apatite occurs in slender hexagonal needles mostly in the quartz but also in the feldspar and hornblende; and a number were obseved which were common to both feldspar and quartz. A few zircons showing parallel extinction, deep black border and brilliant polarization colors also occur. A few colorless, rounded, isotropic grains, probably garnets were observed. Nearer the contact where the rock is much finer grained the typical diabase structure is much better developed, the feldspar having its usual lath-shaped character with augite in allotriomorphic structure around it, although the character of the latter is obscured by its extensive alteration into hornblende. The augite so far as it is revealed in the cores of the hornblende occurs both in simple individuals and in polysomatic masses, and it is interesting to note that the hornblende derived from a polysomatic aggregate of augite is of uniform orientation throughout. Magnetite or titanic iron with associated leucoxene is generally distributed. The quartz is in small grains proportioned to the finer grained texture of the rock. In the central part of the dyke the quartz is in large grains commensurate with the increased size of the feldspar and augite. In neither case does it occur in the mosaics which are so characteristic of the secondary or vein quartz. In addition to

the minerals enumerated in this part of the dyke, there is in prominent porphyritic development an altered rhombic pyroxene. The alteration has proceeded very far and the mineral is now represented only by a mass of yellowish green serpentine with perhaps some of the intermediate alteration product bastite. The cleavage is, however, well defined and the extinction in the several cases noted is sharply parallel to it. These characters together with the traces of the obtuse dome so characteristic of sections of enstatite are sufficient to identify it as that mineral in an altered state. The occurrence of the enstatite in this dyke in its finer grained parts towards the contact is analogous to, and an interesting confirmation of the similar occurrence of the mineral noted in the Jack Fish lake dyke also in the vicinity of its contact.

To summarize, the main points of interest are, briefly: 1. Post Archæan age of dykes. 2. Their problematic relationship to traps of the Animikie and Keeweenawan. 3. Their uniform strike and width. 4. Sharp contact. 5. Passage from coarse texture at centre to aphanitic at sides. 6. Granular character towards centre, porphyritic at sides. 7. Prevalence of quartz and garnets towards centre, and absence near contact. 8. Presence of enstatite at sides, absence towards centre. 9. "Chloritic substance" abundant at sides, absent towards centre. 10. Polysomatic character of augite throughout. 11. Uralitization of augite. 12. Very marked contrast of texture of two different parts of a rock mass which solidified under practically the *same pressure* but at *different rates of cooling.*

[*Proc. Can. Inst. Toronto, 1887.*]

DARWIN AND GEOLOGY.

BY PROF. E. W. CLAYPOLE.

(*Continued from p. 162.*)

In the comparative seclusion afforded by his five years on the "Beagle"[1] the mind of Darwin gradually drifted toward the

[1] In connection with the immense amount of work performed in later years we may note that his health was never good after this voyage. The cause does not seem to have been evident. Speaking of a little tour

ground on which at last it came to rest. It is not our duty here to follow the story. Its results were mainly biological, though the indirect results to geology were important.

The earliest of these was his theory of coral-reefs on which, in view of some recent discussions a few words will be in place.

The formation of coral-reefs and coral-islands had long been an unsolved problem. The opinion entertained by most writers on the subject had been that these islands and reefs incrusted the tops of submarine mountains, and this was adopted and advocated by Lyell in the earlier editions of his "Principles." Their great number and size however, militated strongly against the theory; but it held its ground in default of anything more satisfactory.

From some observations made during his voyage Mr. Darwin was led to propose another hypothesis. He suggested that coral-islets of all kinds were based on the tops of slowly subsiding mountains which formerly reached or rose above the surface. On this view the polyps began their work when the peak was not more than 120 feet under water, and by the constant secretion of limestone maintained it at that level, subsidence notwithstanding. As the growth of coral is most rapid in the open sea so the outer edge of the encircling reef grew fastest and rose, while the inner parts, being shut off from the free food and abundant calcareous supply of the open water, flourished less and ultimately died. In this way as the land sank and became smaller the reef became more distant and all the various stages between the circling line of coral and the perfect atoll were developed, or in the case of a large tract of land such as Australia, the great barrier reef that borders its north-eastern coast for about a thousand miles, was the result.

Such was the simple and beautiful solution proposed by Darwin for a problem which had been previously unsolved. Its simplicity and beauty won for it immediate popularity and it remained for many years almost undisputed.

The vastness of the main postulate on which Darwin based

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which he made in 1842 at the age of 33 he says: "This was the last time I was ever strong enough to climb mountains or take long walks such as are necessary for geological work.'

his theory was however in the minds of not a few geologists a serious difficulty. The subsidence of so large an area of the surface of the earth as was required could not be admitted without serious misgiving. There was no evidence sufficient to prove it, nor was there at that time any weighty objection against it. The difficulty was not unfelt, though for many years it was unexpressed. It lay dormant, so to speak.

Within recent years however there has grown up a school of geologists or geological physicists who are disposed to carry the uniformitarian theory into the continental history of the earth. They maintain that the division into land and water is one of the original lines of geographical development which, with minor changes especially around the borders, has remained unaltered to the present time. To geologists of this school—Stabilitarians, as they may well be called—the fundamental postulate of Darwin was especially obnoxious, as it involved the practical disappearance of a continent and the formation of an ocean within quite geological times.[1] Yet as nothing better was suggested the theory held its ground, strengthened as it had been by the powerful influence of Lyell, who adopted and defended it in the edition of the "Principles" published in 1853.

After the return of the "Challenger" from her voyage of discovery in the southern seas, Mr. John Murray, one of the naturalists who went out in her brought forward in 1880 a different theory, free from the fundamental objection above pointed out, which seems to be gaining favor among geologists. It has recently been the subject of a somewhat acrimonious skirmish in the columns of "Nature."[2]

Mr. Murray after an examination of coral islands in the East Indies and Indian ocean, fails, as others before him had done, to find any evidence of the subsidence required by the theory of Darwin. On the contrary both he and they find in many cases abundant evidence of elevation. Recollecting also that in no

[1] It is true that Darwin carefully guarded against being supposed to favor the previous existence of a continent in the Pacific area (see Life, p. 435) but the amount of subsidence required by his theory is so great that it would actually exceed that needed for some of the creations of the school of geologists here alluded to.

[2] Nature, 1887. "A conspiracy of silence."

single instance has any trace been found of a sunken mountain peak as the base of a coral islet, (for oceanic islands are uniformly volcanic,) Mr. Murray proposes as the foundation of his theory, the elevation of the higher portions of the sea-bottom by deposition of organic material or by volcanic action, until they come within the limit of reef-forming polyps. Then the principles already mentioned, of faster growth on the margin and of death and erosion in the center, will do all the rest and produce in time the fringing reef and the atoll.

Though it is obvious that Mr. Murray's theory gains enormously by being free from the fundamental objection to that of Darwin, and is strong just where the latter is weak, yet it would be premature to say that it has yet found general acceptance. The geological world is divided, as is conclusively shown by the controversy above alluded to, and this is not the place for the expression of individual opinion. Both may be true in different places.[1]

It should however be mentioned that in another point the later theory enjoys a considerable advantage over the earlier. The unfathomable depth of water so often reported close to the edge of a reef was evidently a natural and necessary consequence of its mode of formation according to Darwin. But this depth seems from recent soundings to be fictitious or at least non-existent. The edge of the reef, it is true, falls off to seaward very steeply for a short distance, after which there follows a gradual slope not exceeding six degrees of inclination, and just such as might be looked for on a submarine bank. This bank at no very great distance from the reef ceases to be composed of coral and yields to the dredge nothing but volcanic dust, apparently the comminuted ejecta of some submarine vent.

Passing from this topic of coral formation where we find Darwin invoking the most extensive subsidence, in time comparatively recent, that has perhaps ever been suggested, it is not a little interesting and certainly amusing to note the indig-

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[1] A good summary of the two theories and much other interesting material of a kindred nature may be found in "Nature" for November, 1883, from the pen of Dr. Archibald Geikie.

nation with which in later and more mature years he met the appeal of other geologists to similar means of escape from difficulty. Edward Forbes was the most daring member of this school, which, in order to explain certain facts in the distribution of animals and plants, did not scruple to conjure up continents in several parts of the globe now occupied by deep sea, and where the soundings afford no base whatever for such creations. Thus "Lemuria" was imagined to extend across the Indian ocean from the East Indies to Madagascar, while another continent built by the same "pontifex" Forbes, extended from Europe to North America, and yet a third to the "Sargasso bank." Hooker in like manner called into being a long bridge from New Zealand to South America and thence on to Kerguelen Land almost girdling the earth in that latitude. These were constructed for the convenience of species whose resemblance to others at distant points could not be explained without some means of migration. Instability with these geologists became the law of continental evolution, and the geography of the earth in their hands changed so rapidly and so frequently as to remind the spectator of a kaleidoscopic exhibition. Even Lyell fell under the spell of these views for awhile in spite of his strong uniformitarian proclivity. But Darwin's work had led him in a different direction. His observations had shown him that the distribution of animals and plants was not so dependent on continuous land surfaces as these naturalists supposed. He had found that the chapter of accidents could be depended on for a vast number of exceptions to the general rules, and he had learned to trust it firmly when no clear connection could be found. His belief in orderly sequence and regular developement even of geographical outlines was unshaken, and the balance of his judgment went against catastrophe even here. Hence his indignation at the "feats" of Forbes, Hooker and others of the same school, and at last with his old master Lyell himself. In 1856 he wrote to the latter:

"My blood gets hot with passion and turns cold alternately at the geological strides which many of your disciples are taking." "Woodward writes that if you grant a continent over two or three hundred miles of ocean depths (as if that were nothing) why not extend a continent to every island in the Pa-

cific and Atlantic oceans? All this within the existence of recent species! If you do not stop this, if there be a lower region for the punishment of geologists, I believe you, my great master, will go there. Why, your disciples in a slow and creeping manner beat all the old Catastrophists who ever lived. You will live to be the great chief of the Catastrophists."

In a subsequent letter he adopts a different tone, and dissecting mercilessly the evidence adduced by these continent-mongers, he shows its insufficiency to prove their point and avows his adhesion to the party that asserts the stability of the great main lines of the earth's geography, adding that he would much like to be convinced by the arguments of his "master" but finds it impossible. Here again Darwin's sagacious "anticipation" was ahead of Lyell's caution.

It is scarcely necessary to add that all these vast continental extensions have again sunk below the sea level leaving not a solitary oceanic islet or reef of secondary or palæozoic rock to mark the place of their supposed existence. The theory that made possible the "Lemuria" and the gulf-weed continent of Forbes, and Antarctic bridge of Hooker is as dead as — —'s Atlantis.

We now approach the great event of Darwin's life, but as it only concerns us indirectly we shall not dwell on the circumstances attending it. They are moreover by this time so well known that to detail them would repeat an oft told tale. In 1859 appeared the "Origin of Species," in biology the most epoch-making book of the passing century. Its importance lies in the fact that in it was shown to the world for the first time, and shown with a wealth of fact and argument that defied refutation, a real and active cause for the transmutation of species. The struggle for existence, a factor which, strange to say, had hitherto escaped due notice, supplied the long lacking key to this hitherto tantalizing problem. The flash of anticipation that lighted the mind of Darwin on reading Malthus's "Essay on Population" was like the flash that went through the mind of Newton when the apple fell. The "Law of Variation" deduced by the former has been as momentous and as wide-reaching in the world of life as the "Law of Gravitation" announced

by the latter has proved in the world of matter. Here at least was a clue to the maze of species and varieties among which the student of nature was rapidly losing his way—a beacon-light to guide him through the darkness, a leading principle that could bring order out of all this chaos. Evolution propelled by variation and guided by natural selection seemed capable of accounting for most of the difficulties in the existence and distribution of organic forms far better than any other cause, even than special creation. It was therefore the one which biologist in all fields were logically bound to adopt. Into the story of its struggle and final victory it is not our purpose here to enter. With one more point our sketch can come to a close.

During the prosecution of his work Darwin of course contemplated the acceptance with which a theory so new and so opposed to existing beliefs and prejudices would be received. He knew enough of the conservative tendency of the human mind even among men of science to look forward with no little anxiety to the day of publication. He had seen in Edinburgh the effect of prepossession and prejudice. When at length the "Origin" appeared nothing surprised him less than the fierce denunciation and sullen displeasure that greeted it from the conservative "Many" or than the timid and guarded approval of the liberal "Few." Foreseeing it, he had mentally chosen three men whose support, if he could win it beforehand, would in his opinion, outweigh the condemnation of all the rest of the world. These were his old master in geology, Sir Charles Lyell, then rising to the full hight of his great fame and with a reputation of no mean value to stake on the result, Sir J. D. Hooker, late director of the royal gardens at Kew, the botanist with perhaps the widest experience of all then living in England, and a young man just coming into note as a zoölogist but of whose power Darwin entertained a very high estimate, an estimate fully justified by the result for he has been the fighting apostle of the new faith—Thomas H. Huxley. To produce conviction in the minds of these three men Darwin labored hard and eventually succeeded, so that when the first outlines of the Theory were read to the Linnæan Society, and the whole force of the conservatives prepared to assail it with

every available weapon, they were somewhat daunted to find that they must measure swords not with a man comparatively unknown to fame and of whose opinions and observations they could as they believed, make light work, but with Lyell, Hooker and Huxley, who like the three brave Romans of old stood forward to defend the narrow way until the new truth could make itself felt and win its own adherents. Of this famous meeting of the Linnæan Society, on July 1st. 1858, when the subject was first broached, Sir J. Hooker writes (p. 482):

"The interest excited was intense but the subject was too novel and too ominous for the old school to enter the lists before armouring. After the meeting it was talked over with bated breath; Lyell's approval and perhaps in a small way mine as his lieutenant in the affair rather overshadowed the Fellows who would otherwise have flown out against the doctrine."

With only one of these three have we any concern now and that is Lyell. The intimacy between him and Darwin had been long and close, and Lyell was familiar with every step of the way along which his friend was traveling. Every new fact was told to Lyell. Lyell's opinion was asked on every topic—not always agreed with however. In Lyell's mind there slowly grew up as firm a conviction that Darwin was right as was entertained by Darwin himself, and when the "Origin" appeared Lyell was fully prepared to go the utmost length that the doctrine of "Evolution by Natural Selection" would warrant. He gladly welcomed the new light from biology and saw at once its power of illuminating certain dark spots in his own favorite science. He had halted at the evolution of organic species because Lamarck could show no good reason for the necessary changes. But he now halted no longer. Natural Selection supplied the missing cause, and he at once connected it with the effect. He had no further use for the doctrine of "Special Creation" and it disappeared from the pages of his "Principles," its place being supplied by Variation. Here was the harvest that grew from the seed sown by Henslow. The reaction of the pupil on the master was now seen and Darwin amply repaid the debt which he owed to Lyell.

It is interesting to note the difference of expression in the

editions of Lyell's "Principles" published after the appearance of the "Origin." While fully adopting the new views therein propounded, the caution of his character is manifest in his mode of writing of them. Thus in the edition of 1872 he says, in striking contrast to the extract given above from that of 1853:—

"In former editions of this work I did not venture to differ from the opinion of Linnæus that each species had remained from its origin such as we now see it, being variable but only within certain limits." "But I undertook to show that the gradual extinction of species one after another was part of the constant and regular course of nature." "I suggested also that the coming in of new species was also probably successive."

"In truth there are as yet only two rival hypotheses between which we have to make our choice in regard to the origin of species—namely, that of special creation and, that of creation by variation and natural selection."

Again, speaking of the facts of geographical distribution, he says: "They accord well with the theory of variation and of natural selection, but with no other hypothesis yet proposed for explaining the origin of species."

But the crowning proof of the influence of Darwin over Lyell was given when the "Antiquity of Man" appeared in 1863. It is easy to see from the general tenor of this work that Darwin's doctrine had sunk deep into the mind of the great but formerly half-way-halting Uniformitarian teacher. Though here, as everywhere else, writing with caution it is manifest that he was then prepared to go to the full length required by the theory of variation as expounded in the "Origin." He had even risen superior to the great difficulty, partly arising from prejudice and partly from tradition—the difficulty of admitting that man himself was held in the toils of the evolutionary net and that he was himself a link in the long chain of organic beings—the last and greatest but still only a link.

He says in some memorable words, more memorable still when we remember the date of their publication.

"A theory that establishes a connection between the absence of all relics of vertebrata in the oldest fossiliferous rocks and the presence of man's remains in the northwest; which affords an explanation of the successive

appearance in intermediate strata of fishes, reptiles, birds, and mammifers, has no ordinary claim to our favor, comprehending as it does the largest number of facts that science has perhaps ever attempted to embrace in one grand generalization."

"But will not transmutation if adopted, require us to include the human race in the same continuous series of developments so that we must hold that man himself has been derived by an unbroken line of descent from some one of the inferior animals? We certainly cannot escape from such a conclusion without abandoning many of the weightiest arguments which have been urged in support of variation and of natural selection considered as the subordinate causes by which new types have been gradually introduced into the earth."[1]

These are most remarkable words coming as they did from the leading geologist in England, with a high reputation to risk by taking up a new, and in the minds of most a transcendental and irreligious, theory; and the man who at that day dared thus to speak deserves the gratitude of not only every geologist but of every lover of truth to whatever science he devotes his attention. Even those who follow no science owe not less a debt of gratitude to him who faced the obloquy and the odium that then awaited all who ventured to acknowledge connection with the new school of Evolutionists. It is difficult now to realize the fact, but it is within the memory and experience of men not beyond mid-life—when the "Antiquity" and the "Descent of Man" were spoken of with bated breath as forbidden subjects, and when those who thought or spoke on those topics were viewed askance as "suspects" with whom it was not well to be associated. But so it was, as many can testify from experience. Such days can never return. No more questions so momentous remain to be solved in geology. The battle has been fought and the victory won. Evolution is now the keyword to nature and we of these days can only look back to that time and live it over again in memory, while of the later generation we can say, as we said at the beginning of this paper, "Other men labored and ye have entered into their labors."

NOTE. Though it is a little off the main line of this paper yet it is timely and pleasant at the present moment when America is mourning the loss of her great botanist, to allude to the share which Dr. Gray contributed to the "Origin of Species." Darwin began a correspondence with him through Hooker which afterwards became constant and intimate. The

[1] *Antiquity of Man*, *1860.*

philosophic mind of Gray was strongly attracted by the breadth and scope of the views of Darwin, and came rapidly under the spell of their influence. To him Darwin was indebted for many facts both in favor of and in opposition to his theory of natural selection. Both were equally welcome. The attachment of the two men was mutual. In one of his early letters Darwin writes: "You are more than anyone else the thorough master of the subject. You know my book as well as I do myself and you bring to the question new lines of illustration and argument in a manner which excites my astonishment and also my envy. Every word seems weighed carefully and tells like a 32-lb. shot." It fell to the lot of Asa Gray to fight the battle of evolution in America almost single-handed against the immense influence of Agassiz, who while opposing the doctrine to the last contributed by his embryological studies some of the most powerful arguments in its support. Dr. Gray entered the field alone but from the first he gave no uncertain sound. Though he never went to the full length with his friend, always maintaining that the stream of variation had been, as he phrased it, "beneficially directed," yet in 1860, or the year after the appearance of the "Origin," he wrote three articles in the Atlantic Monthly which now form the third chapter in his "Darwiniana," under the heading, "Natural Selection not inconsistent with Natural Theology." With this limitation Dr. Gray continued among the foremost and most consistent advocates of Natural Selection in this country to the time of his recent death;[1] but as his application of the doctrine was almost entirely to the science of botany to dwell longer on it here would scarcely be in place.

ON THE OCCURRENCE OF LATER CRETACEOUS DEPOSITS IN IOWA.

BY CHARLES A. WHITE.

The existence of Cretaceous strata in western Iowa has long been known; and they have been discussed and referred to by various authors. Those which are exposed in the neighborhood of Sioux City were first recognized as of Cretaceous age by Owen;[2] and for several years thereafter no other exposures were known to exist within that state. In the course of my official work upon the geology of Iowa other exposures of Cretaceous strata in situ were discovered at localities farther eastward from the Missouri river. The more southerly of these exposures, as well as a part of those in the vicinity of

[1] January 30th, 1888.

[2] See maps of Geol. Survey of Wisconsin, Iowa and Minnesota.

Sioux City, were recognized as belonging to the Dakota group; while the more northerly exposures were referred to the next higher portion of the earlier Cretaceous.

Besides these exposures of strata in situ numerous fragments and scattered fossils were from time to time found at different localities in the drift, some of which localities are much farther to the eastward than are any of the exposed strata referred to. These latter traces are so numerous and so widely distributed, and the known dips and trends of the older formations are such that, in my official report, I deemed it proper to represent a large part of western Iowa as occupied by Cretaceous strata,[1] though mostly covered from sight by the abundant glacial drift which prevails there.

Subsequent discoveries have tended to confirm the correctness of this view; and even to extend the limits of the area in Iowa which may be properly regarded as now, or as having formerly been, occupied by Cretaceous strata.[2] These later discoveries have been mainly, not of strata in situ, but of such fragments of fossiliferous strata, and of separate fossils, in the drift of that region, as have just been referred to. Many of these specimens are so soft or so fragile; or they have suffered so little attrition, as compared with that which the transported material associated with them in the drift has suffered, that it seems necessary to assume that those specimens were not transported to any considerable distance from the place of their original deposition. An account of one of these discoveries was published by me several years ago,[3] and the primary object of this article is the announcement of another.

A short time ago Prof. Erasmus Haworth of Penn College, Oskaloosa, Iowa, informed me of the discovery of a mass of fossil-bearing rock in the digging of a well in the drift of Hardin county, Iowa.[4] He recognized these fossils as of Cretaceous

[1] See White, C. A., Geology of Iowa, vol. i, p. 287; geological map in vol. ii, and geological map-model, vol. i, facing page 32.

[2] See also accounts of the discovery of Cretaceous deposits at numerous localities in southern Minnesota in Winchell's Minnesota reports.

[3] See White, C. A., on the eastern limit of Cretaceous deposits in Iowa. Proc. A. A. A. S., vol. xxi, p. 187-192.

[4] The locality given by Prof. Haworth is, Sec. 17, township 86 N., range 20 west of the 5th, P. M.; which is not far from the center of the state.

age; and at my request he kindly sent them to me for examination. The fossils consist of molluscan remains, which are imbedded in fragments of firm ferruginous sandstone; and these fragments indicate that they are portions of highly fossiliferous strata. The specimens are all more or less imperfect; but the generic character of the greater part of them is satisfactorily recognizable, and a part of them have been specifically identified with published forms. The following is a list of the forms so far as they have been generically determined. Besides those mentioned in the list, two or three other forms are indicated by small fragments of shells.

LIST OF SPECIES.

Inoceramus ———?
Pinna lakesi White?
Syncyclonema rigida Meek and Hayden?
Nucula ———?
Callista? ———?
Corbula inornata M. and H.
Dentalium ———?
Chemnitzia cerithiformis M. and H.
Pseudobuccinum nebrascene M. and H.
Lispodesthes? haworthi sp. nov.

The specimens representing *Inoceramus* are mere fragments, giving no indication of the form of the shell, and therefore none of its specific identity; but they show the characteristic shell-structure of that genus. The *Pinna* is represented by a number of fragments which I have little doubt represent *P. lakesi* White, from the Fox Hills group of northern Colorado.[1] The single specimen referred to *Syncyclonema rigida*[2] is imperfect, but the identification is probably correct. The specimen referred to *Nucula* shows little or nothing of the external form of the shell, but the characteristic dentition is discernible. Some small separate valves, evidently belonging to the Veneriidæ, are referred doubtfully to *Callista*. *Corbula inornata*[3] is somewhat satisfactorily identified. The *Dentalium* is one of those com-

[1] See 12th Ann. Rep. U. S. Geol. Surv. Terr., p. 17, pl. 11, fig. 1.

[2] U. S. Geol. Surv. Terr., vol. ix, p. 27, pl. 16, figs. 5, a b. This form was originally found in the Fort Pierre group, but it has since been found in strata of the Fox Hills group.

[3] U. S. Geol. Surv. Terr. vol. ix, p. 245, pl. 30, figs. 4 a-d.

mon plain forms which occur in various formations, and which have few salient specific characters. The identification of *Chemnitzia cerithiformis*[1] and *Pseudobuccinum nebrascense*[2] has been quite satisfactorily made. The remaining species is regarded as new, and is described in a following paragraph.

The general character of this little collection of fossils is alone sufficient to suggest their affinity with the fauna of the Fox Hills group, the uppermost member of the marine Cretaceous series of the interior region of the continent. The specific identification of a part of the species of this collection, with formerly published characteristic forms of that group however, leaves no room for reasonable doubt upon that question.

Genus LISPODESTHES White.

Lispodesthes? haworthi sp. nov.

Shell of medium size; body subfusiform, wing large and prominent; spire prominent; the small apex usually made somewhat obtuse by the deposition of callus; the whole surface of the shell covered by a greater or less thickness of callus; but which is a little thinner upon the back of the body volution than elsewhere. Where the callus is removed from the volutions of the spire they are seen to be moderately convex, about six in number, and marked by numerous revolving raised lines, which

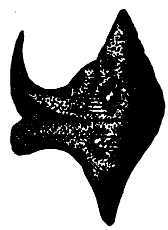

Fig. 1. Dorsal view of Lispodesthes? haworthi; natural size.

are continued upon the body volution beneath the callus there. No revolving ridge appears upon the volutions of the spire, but one is developed upon the back of the body volution and is continued out upon the falciform process of the wing; beak moder-

[1] Ib. p. 339, pl. 32, figs. 10, a, b.
[2] Ib. p. 350, pl. 31, figs. 5, a, b, c, d.

ately prominent; posterior canal absent, but there is instead, a moderately broad notch at the junction of the posterior margin of the wing with the spire. The lower lobe of the wing is prominent, thickened, and rounded at the outer end; the falciform process long, pointed and curved outward and backward. The general shape and size of the shell is indicated by the accompanying figure.

The shell, in general aspect and in many of its details, is closely like *Lispodesthes nuptialis* White, from the Cretaceous of Arizona. It has all the characteristics upon which the genus *Lispodesthes*[1] was proposed except the posterior canal, which in the type species is grooved out of the callus covering the spire, and which extends nearly to its apex. In this species however there is no such groove, but its other characteristics agree so closely with those of *Lispodesthes* that I refer this form to that genus, at least provisionally. The specific name is given in honor of Prof. Haworth who brought these fossils to my notice.

In my former discussions of the Cretaceous deposits within the state of Iowa I have been disposed to treat them all as belonging to the "Earlier Cretaceous" of Meek and Hayden; that is, as being older than the Fort Pierre and Fox Hills groups. It is true that Mr. St. John regarded certain of the fish remains which were found associated with Cretaceous mollusca in the drift of Howard county as indicating a very late epoch of the Cretaceous, although he was not able to identify any of them with published species.[2]

While the value of the evidence furnished by the type characters of those fish remains was not overlooked, the lack of specific identification of any of them with forms whose stratigraphical position was known left the question as to whether they were of earlier or later Cretaceous age open to at least reasonable doubt Because of this, and of the fact that the fossil mollusca which were associated with those fish remains seemed to be, in part at least, specifically identical with forms which characterize certain of the earlier Cretaceous strata in

[1] For the original generic diagnosis see U. S. Geog. Surv. (Wheeler's) West of the 100th Meridian, vol. iv, p. 191.

[2] See article before cited, Proc. A. A. A. S. vol. xxi, p. 188.

the region adjacent to western Iowa, I adhered to my previous opinion that they were all of earlier Cretaceous age.

I was influenced by those impressions while discussing in a late publication,[1] the shifting position of the eastern shore line of the mesozoic seas which prevailed in what is now the interior of North America. I there expressed the belief that the Cretaceous shore line finally receded to the westward of western Iowa at the close of the Colorado epoch of the earlier Cretaceous. Now, however, the fossils found in Hardin county seem to warrant the opinion that the final recedence to the westward of Iowa of the Cretaceous shore line occurred as late as the closing epoch of the later Cretaceous. That is, not only is the general character of all those Hardin county fossils suggestive of their affinity with the molluscan fauna of the Fox Hills group, but two of them have been specifically identified with characteristic fossils of that gronp; and of the specific identity of three others there is apparently little room for doubt.

It is not to be denied that if the fossils discovered in Hardin and Howard counties had been obtained from strata undeniably in situ, the evidence furnished by them would be more satisfactory. It would also be more satisfactory if it were supported by a large number of similar discoveries; and in the estimate which I put upon the value of these, the anticipation of future discoveries, even of strata in situ, is taken into account. Even in view only of the discoveries already made in Iowa and in Minnesota, a portion of which have been mentioned in previous paragraphs, one can hardly entertain a reasonable doubt that considerable deposits of later, as well as earlier Cretaceous strata were made far within the present limits of the state of Iowa.

Although the meridian position of this Hardin county locality is more westerly than that of Howard county, it is much more easterly than is any other known Cretaceous locality in Iowa south of the northern tier of its counties. If, therefore, we regard the Hardin county fossils as having been originally deposited where they were found, this discovery materially extends the known eastern limit of Cretaceous deposits in that state. It is fully believed that those fossils were originally deposited at,

[1] See White, C. A., On the Fresh Water Invertebrates of the North American Jurassic. Bul. U. S. Geol. Survey No. 29, p. 14.

or very near the place where they were found; but even if they have been transported by drift agency, their original position must have been fully as far to the eastward as that in which they were discovered.

The known position of the older Iowa formations, considered with reference to the land surface, seems to indicate that the maximum thickness of all the Cretaceous deposits which occurred within that state was much less than that which was reached by those formations further westward. But if we take into consideration the probable fact that those deposits were exposed to the usual process of subaërial degradation during the whole of the Tertiary period; and that they were afterward exposed to glacial action, we readily perceive that a large part of the material originally deposited within the boundaries of Iowa may have been carried away. Still, the presence there of the later Cretaceous strata, indicates that the earlier ones have always had a comparatively small maximum thickness.[1]

After all the erosion which those strata have suffered, it is probable that at least in the northwestern counties of Iowa, there is still sufficient space between the drift deposit above and the paleozoic formations beneath, to allow of the presence there of several hundred feet in thickness of Cretaceous strata. We may therefore reasonably expect that the numerous excavations that will yet be made in that great drift-covered region, will result in the discovery there of some strata in situ. We may also expect to learn of many other discoveries similar to those of Hardin and Howard counties, in districts where small patches of Cretaceous strata have escaped destruction.

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[1] Just as this article is going to press I have received a note from the veteran paleobotanist, Prof. Lesquereux, concerning a leaf impression submitted to him, which was included in Prof. Haworth's collection. This form is unhesitatingly referred by Prof. Lesquereux to Andromeda parlatorii Heer, a characteristic species of the Dakota group. This may be taken as an indication that the earlier, as well as the later Cretaceous reached as far eastward as central Iowa.

ON SCEPTROPORA, A NEW GENUS OF BRYOZOA, WITH REMARKS ON HELOPORA HALL, AND OTHER GENERA OF THAT TYPE.

BY E. O. ULRICH.

Nearly a year ago Prof. J. F. Whiteaves the palæontologist to the Canadian geological survey, kindly sent me for examination and description a box of fossil bryozoa which had been collected from Lower Silurian rocks in Manitoba.

Among other interesting forms, I have found the surface of some of the slabs strewn with the separated segments of an undescribed species and genus of jointed bryozoa.

On my return from Minnesota last October, I stopped over for two weeks in Illinois to study the Lower Silurian outcrops in the northern part of that state, and at two localities, Savannah and Wilmington, was so fortunate as to find a number of isolated segments of the same form. The Lower Silurian rocks at these two localities are doubtlessly equivalent to the upper half of the Cincinnati group (Hudson River) of Ohio, many of the fossils found in the western localities being identical with well known species known to be confined to the upper beds of the group in Ohio.

The equivalence of the rocks at Stony mountain, the locality in Manitoba which furnished the first specimens of the bryozoa in question, is as little doubtful as that of the Wilmington or Savannah strata, many of the fossils being identical with those collected by me at the Illinois localities.

The genus and species may be described, briefly, as follows:

SCEPTROPORA n. gen.

Zoarium articulated; segments numerous, short, sceptre or club-shaped, the lower half striated, non celluliferous, its extremity bulbous; upper half more or less expanded, celluliferous, and with a large socket at the center of the top; occasionally with two sockets when the segment had articulated with two succeeding joints. Zoœcia sub-tubular, radially arranged about a central axis, their apertures subovate, and arranged between vertical lines.

Segments club-shaped, varying in length from less than

1 mm. to nearly 2 mm.; lower half sub-cylindrical, about 0.23 mm. in diameter, non-celluliferous, covered with fine, granulose, vertical striæ; lower extremity bulbous, smooth; upper half celluliferous, expanding more or less rapidly, the depressed-conical top varying in diameter from 0.7 to 2 mm. The zoœcia

SCEPTROPORA FACULA n. sp.

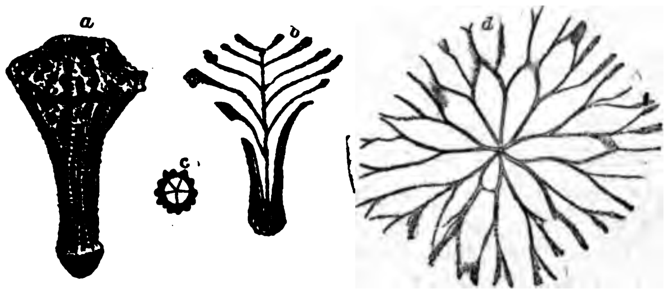

Fig. 1. *Sceptropora facula*, n. sp., *a*, segment of the average size and appearance; *b*, vertical section of a segment, showing tubular zoœcia and central axis; *c*, transverse section of the cylindrical lower half of a segment; *d*, transverse section of expanded portion of the largest segment seen. All magnified to 18 diameters.

apertures on the top are sub-circular, about 0.09 mm. in diameter and arranged in radial series between raised lines about the large central socket. As the zoarium expands the series increase in number by interpolation. The zoœcia apertures on the sides are ovate and a little larger, having an average length of 0.11 mm. Like those on the top, they are arranged between elevated granulose ridges.

Remarks: The detached segments of this very pretty little bryozoan are abundantly strewn over the surface of some of the slabs from Stony mountain, Manitoba, and I do not doubt that if searched for, specimens preserving a number of them joined together would be found there. Such must be looked for in shaly layers only. Among the Savannah specimens there is one consisting of two segments still joined together. Those from Wilmington consist of isolated segments. Here they are neither abundant nor easily detected, being, because of their small size and the peculiar character of the rock, readily overlooked.

The systematic position of *Sceptropora* is clearly near *Helopora* in the family *Arthrostylidae.*[1] This family especially in its most typical members, reminds us of the *Cellariidæ*, yet, beyond the jointed zoarium and a general external resemblance, but little can be brought showing true relationship. On the contrary, in the form and minute structure of the zoœcia, they agree closely with the *Stictoporidae.*[2] One of the most marked peculiarities of that family is the presence of exceedingly minute tubes between the median laminæ. In the *Arthrostylidae* the zoœcia are nearly always arranged in a radial manner about a central axis. Here a minute vertical tube has been detected in exceptionally preserved examples of several species, and in at least one species, two such tubes. In *Arthrostylus tenuis*, in which the zoœcia open on only three sides of the subquadrangular segment, the fourth and widest side being simply striated longitudinally, the minute axial tube is situated at the point of union between the proxinal ends of the three rows of zoœcia. This axial tube, or tubes, I regard as homologous with the "median tubuli" of the *Stictoporidae.* Another feature common to members of that family, and many of *Arthrostylidae*, is a row of minute vertical tubuli, which occur, particularly in the outer portion of the zoarium, between the rows of zoœcia, and appear at the surface as minute granules on the dividing ridges between the rows of superficial apertures. Precisely the same kind of structures are shown in *Sceptropora facula* (see fig. 1, a) and less well in section of *Helopora fragilis* (fig. 2. *c*). The primitive or deeper portion of the zoœcia is, of course, different in the two families, it being wedge shaped and generally longer in the *Arthrostylidae* than in the *Stictoporidae.* These differences, however, are accounted for by the different form of zoarium characterizing them. Thus,

[1] The name *Arthrostylus* is proposed instead of my *Arthronema* ("Am. Pal. Bry." Jour. Cin. Soc. Nat. Hist. vol. v, p. 160) which was preoccupied by Eschscholtz for a genus of *Colpodea.* The genus being the type of the family *Arthronemidae*, it seems best to change the family name as well.

[2] This family as now understood and defined by me in the forthcoming vol. viii of the Illinois geological survey, comprises the following genera: *Stictopora* Hall, 1847 not 1887, (based on *S. fenestrata* Hall) *Dicranopora* Ul., *Pachydictya* Ul., *Phyllodictya* Ul., *Eurydictya*, *n. gen*: and *Euspilopora* n. gen.

while in the latter the zoœcia form two leaves grown together back to back, in the former they are arranged radially so as to form subcylindrical or club-shaped stems. This mode of arrangement of itself would cause the primitive portion of the zoœcia of the larger forms of the first family to incline to become tubular. The reason is obvious, since nearly all the zoœcia originate at or near the center of the zoarium and being forced to adapt themselves to the distance between the axis and the outer surface, are necessarily longer than in such flat forms like *Stictopora* in which the rapid development of the cells is not retarded by lack of space.

The resemblances above pointed out sufficiently show the position of the family to be near the *Stictoporidæ*, while their relation on the other side again should be sought for among the *Rhabdomesontidæ* rather than the *Callariidæ*, the succession of the forms in geologic ages being an important circumstance greatly favoring the former. There is, however, a wide structural gap between both those families and the *Arthrostylidæ*, so that we are at present justified in claiming the latter as a distinctively Silurian type of which no representatives are yet known in succeeding ages.

The jointed character of the zoarium is the most conspicuous as well as the most important feature of the family, being well shown in all the genera excepting *Nematopora*,[1] a new genus in which the zoarium (very much as in *Ptilodictya*, proper) articulates at the basal extremity only, and above this base forms a continuous dichotomously branching slender stem. In *Arthrostylus* Ul., *Helopora* Hall, and *Sceptropora*, the segments are simple and terminally joined together, each segment giving rise to one or two succeeding joints. The first of these genera is distinguished by having one of the sides non-celluliferous and simply striated longitudinally. In the second the segments are subcylindrical with zoœcia apertures on all sides, while in the third the zoarium is non-celluliferous below and spreads rapidly above.

The typical species of *Helopora* is Hall's *H. fragilis*, a very abundant and characteristic fossil of the Clinton group of Can-

[1] This genus together with a number of species will be described in vol. viii, Illinois geological survey, now in press.

ada. Besides the type species eight others are known to me which are constructed upon the same general plan, four of them Lower Silurian and four Middle and Upper Silurian. These are distributed as follows: *H. spiniformis* Ul., Birdseye, *H. divaricata* Ul., Trenton, *H. imbricata* Ul. and *H. harrisi* James, Cincinnati group, *H. bellula* Bill., *H. armata*, Bill. and *H. nodosa*, Bill.,[1] Anticosti group, and *H. lindstromi* n. sp. from the Upper Silurian rocks of Gotland.

Upon comparison I find that the Lower Silurian species differ from the Upper Silurian and typical section of the genus in having the cell-apertures arranged in longitudinal series between elevated ridges, and the interspaces between the ends of the zoœcia apertures longer. In *H. fragilis* the apertures are rather oblique, oval or subquadrate, and separated by comparatively thin subequal walls. In the Gotland species they are ovate, nearly or quite direct, and surrounded by a hexagonal margin. The Upper Silurian and Anticosti species also have small acanthopores, which, so far, have not been detected on any of the Lower Silurian forms. In short the latter compare more closely in the arrangement of the zoœcia with *Arthroclema* Billings than do the typical species.

It gives me great pleasure to name this species as above, in honor of the talented Swedish palæontologist, Dr. Gustav Lindström, to whose kindness I owe the opportunity of studying this beautiful species. The specimens are more perfect than those of any other species of *Helopora* yet seen by me.

In *Arthroclema*, Billings, the arrangement of the zoœcia is, as has already been intimated, very much the same as in the Lower Silurian species *Helopora*, but the development and combination of the segments in the three species known to me is so peculiar that the distinctness of the two genera can scarcely be questioned. In *Arthroclema*, namely, the zoarium is composed of a large number of subcylindrical segments. These are ar-

[1] In the *Catalogue Sil. Foss. Anticosti*, Mr. E. Billings describes twelve species which he refers to *Helopora*. I have not seen specimens of all of these but from a study of the descriptions I believe I can say safely that with the exception of the three species above mentioned, and possibly *H. formosa* and *H. concava*, none of the others are congeneric with *H. fragilis*. *H. lineata* and perhaps *H. strigosa* and *H. striatopora* belong to *Nematopora*; the others are undetermined.

ranged in a bi-pinnate manner, those forming the central stem being the largest. Each of the primary segments has one or two sockets on each side for articulation with a smaller second-

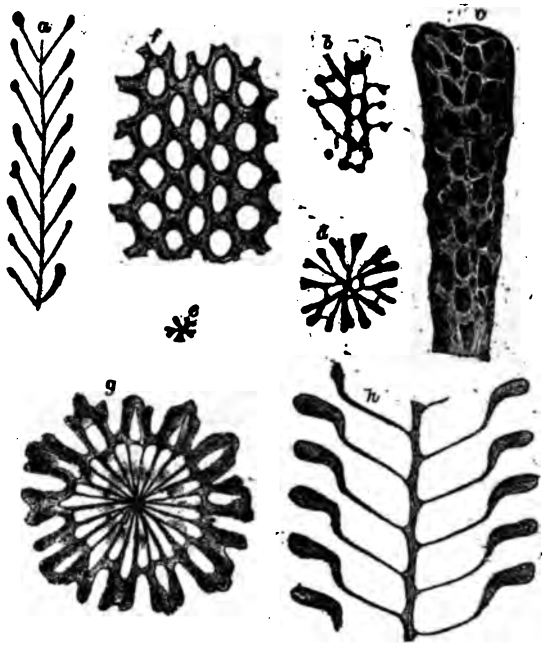

Fig. 2. Thin sections illustrating the internal structure of *Helopora fragilis* Hall, from the Clinton group at Hamilton, Ontario, and *Helopora lindstromi* n. sp.[1] from the Upper Silurian of Gotland.

All the figures are magnified 18 times. *a*, vertical section of small segment of *H. fragilis*, showing the zoœcia as they diverge from the central axis. *b*, small portion of a tangential section of the same, showing acanthopores at the surface. *c*, tangential section of the same, as it appears in the ferruginous matrix; in these examples the extreme outer region is destroyed; this section, however, still shows good indications of acanthopores and, near the center of the figure, a close set row of much smaller pores. *d*, transverse section of the same passing through segment near its upper extremity. *e*, transverse section of the same cutting the segment just above its basal extremity. *f*, tangential section of *H. lindstromi*, showing form and arrangement of zoœcia and acanthopores. *g*, transverse section of the same. *h*, vertical section of the same.

[1] The cylindrical or slightly club-shaped segments of this fine species vary in length from 10 to 15 mm., and in diameter from 1.3 to 1.8 mm. Both extremities are without cells and nearly smooth, the upper one flattened

ary set. These, again, in like manner articulate with still more slender tertiary segments, forming at the same time jointed parallel branches of the primary series of segments.

Excepting in the Trenton beds near Ottawa, Canada, the segments of *Arthroclema* are rarely found still in connection. As the isolated segments closely resemble those of *Helopora* they might readly be mistaken for a species of that genus. They might even be supposed to represent two or three species, since the secondary and tertiary elements are considerably smaller than the primary one. This fact furnishes another point of difference from *Helopora*, since in that genus all the segments are approximately equal. The main difference, however, is found in the two or more sockets that occur on the sides of the primary and secondary segments of *Arthroclema*.

In the typical species of the new genus *Nematopora* the minute characters and zoœcial arrangement closely resemble those of *Arthrostylus*, only the zoœcia open on all sides of the branching stems. The type and several other species are from the Trenton limestone; two species occur in the Cincinnati group, several in the Anticosti, and two or more in the Niagara. Hall's *Trematopora minuta* belongs here.

In the above short sketch I have endeavored to give the student a fair idea of the distinctive characters of the several genera comprised in the *Arthrostylidæ*. On account of the small size of the segments the species will probably continue to be overlooked by the ordinary collector, but he who takes an interest in palæozoic bryozoa should not fail to search for them, as I can assure him he will find them not only an interesting group, but also attractive objects under the microscope. Thin-sections are easily prepared of most of them by simply taking slices of the rock holding them; and none are too small to be thus studied. All of my sections of them have proved more or less instructive and not a few make really handsome micro-objects.

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and slightly concave centrally, the lower moderately convex. Zoœcia arranged in quincunx; measuring lengthwise seventeen in 5 mm.; diagonally, four in 1 m. Apertures direct, oval, with a very narrow peristome, set into a rhomboidal or hexagonal concave area. A rather strong acanthopore generally occupies the space between the ends of the zoœcia apertures.

THE TACONIC SYSTEM AS ESTABLISHED BY EMMONS, AND THE LAWS OF NOMENCLATURE APPLICABLE TO THE SUBJECT.

BY S. A. MILLER.

The term *Taconic system* must be retained for all the rocks existing between those belonging to the Laurentian age and the Potsdam group or base of the Lower Silurian series, if it was properly defined and published prior to the definition of any other geographical name for the same rocks. In other words, the laws of priority, in naming groups of rocks and the so-called systems, must be as rigidly enforced as they are in the naming of fossils and plants, if we are to have system and order, instead of confusion, in geological science. When a group of rocks have been named, and the fossils from them have been described and illustrated so the rocks may be identified by a palæontologist elsewhere than at the typical locality, the name must be retained, to the exclusion of all names subsequently proposed. Synonymy in stratigraphical geology, is quite as odious and objectionable as it is in palæontology, and most of it has resulted from the ambition of those whose work has rather retarded than advanced the progress of science.

The value of the rule of priority, as thus stated, will find no more forcible illustration, than that presented by an examination of the extent of the rocks now under review, and the history of the synonymy to which they have been subjected.

In 1842 Ebenezer Emmons, in his report on the second geological district of New York, described the rocks lying on the sides of the Taconic mountains, parallel with the boundary line between New York and Vermont, under the name of the Taconic system. He found the belt on the western border of the mountains more than fifteen miles wide, and on the eastern side nearly twenty-five miles, making a total of nearly forty miles. The rocks occur in Westchester, Columbia, Rensselaer and Washington counties, and stretching the whole length of Vermont enter Canada and extend beyond Quebec. He mentioned a typical locality in Berkshire, Massachusetts. The general character of the rocks was given as follows:

1. A coarse granular limestone of various colors, called Stockbridge imestone from the quarries at that place.

2. Granular quartz rock, generally fine-grained, in firm, tough, crystalline masses of a brown color, but sometimes white, granular and friable.

3. Magnesian slate.

4. Sparry limestone.

5. Taconic slate, which is extremely fine-grained and only slightly coherent.

He traced the rocks in a north and south course for 150 or 200 miles, and observed the fact that they underlie the Potsdam sandstone, wherever it does not rest upon the gneissoid strata.

In 1844 he published the "Taconic system," reviewed his former work, furnished numerous evidences in support of the existence of these rocks below the Potsdam and above the gneissoid rocks, or what are now known as the Laurentian, and ascertained that they had a thickness, as shown by a single section, of more than two miles. He said, taking one broad view of the whole system, it might be described as consisting of fine and coarse slates with subordinate beds of chert, fine and coarse limestone, and grey, brown and white sandstone; these admitting however, of further divisions. The leading divisions recognized were:

1. Granular quartz or brown sandstone resting unconformably upon the older gneiss. It is the least regular in its continuation of any of the rocks of the Taconic system, and generally appears in isolated mountain masses, as at Oak hill between Adams and Williamstown, Mass., at Monument mountain in the south part of Berkshire, in the east part of Bennington, Vt., and in Dutchess, Putnam and Westchester counties, New York.

2. Stockbridge limestone, generally known as Stockbridge marble and occuring in New York, Vermont, Massachusetts and Connecticut. Commencing at Sing Sing, it runs a northerly course through Westchester, Dutchess and Columbia counties, and extends into Connecticut. It passes up the valley of the Housatonic into the upper valleys of the Hoosic, and onward into Vermont, and is well represented at Williamstown, Massachusetts.

3. Magnesian slate which composes the highest mountains in the Taconic ranges. The range of mountains composed of this slate extending along the western border of Massachusetts and through Vermont, often rising to the hight of fifteen hundred feet, known as the Taconic range furnished the name to this system. It crosses the Hudson about thirty miles above New York city, and passing south through New Jersey enters Pennsylvania.

4. Sparry limestone, a name given to it many years before by Prof. Amos Eaton. It occupies a belt of country in the eastern part of Dutch-

ess, Columbia, Rensselaer and Washington counties, and, passing north, strikes the west line of Arlington, Vermont.

5. Taconic slate, with its subordinate beds of roofing slate and coarse brecciated layers. It occupies almost the whole of Columbia, Rensselaer and Washington counties, and extends to the base of the Taconic range, which separates New York from Vermont and Massachusetts, and has an immense thickness. It crosses the Hudson above Newburg, and passes through Orange county into New Jersey. From the roofing slate he defined *Diplograptus simplex*, and from the Taconic slate in Washington county *Buthotrephis flexuosa*, *B. rigida*, *Palæochorda marina*, *Nemapodia tenuissima*, *Nereites deweyi*, *N. gracilis*, *N. jacksoni*, *N. lanceolatus*, *N. loomisi*, *N. pugnus*, *Myrianites murchisoni and M. sillimani.*

6. Black slate, forming so far as he knew the highest member of the Taconic system, and from which he named and illustrated *Elliptocephalus asaphoides* and *Atops trilineatus.*

He identified the Smithfield limestone in Rhode Island with the Stockbridge limestone, and an accompanying slate with the Magnesian slate; and in Blackstone valley he found the brown sandstone and fine granular quartz. He recognized in the slates in Waterville, Maine, the Taconic slate of New York, and found the *Nereites*, at Kennebec. The fine roofing slates on the Piscataqua he found subordinate to the Taconic slate in like manner as they exist in New York. And, jointly with Douglass Houghton, the Taconic system was found largely developed in the upper peninsula of Michigan; the slates of the formation with their fucoidal impressions and the granular quartz were both recognized. In 1846 he reproduced his work on the Taconic system in a report on the Agriculture of New York, with an appendix describing a conglomerate at the base resting unconformably upon granitic rocks.

In this manner this geological subdivision was first determined, defined and established, and it should have been recognized from that time forward. But others, much less informed, disputed the existence of the rocks, erroneously referred his fossils to more recent genera, and some, finding the same rocks, gave to them different names, which added to the confusion, and seriously retarded the progress of knowledge respecting them. It may be that later researches have not, in every respect, sustained his determinations, but Ford's work near Albany, New York, where the position taken by Emmons was most violently assaulted, has not only corroborated him,

but has forever set the question at rest, in that locality; Wing, Dale and Dwight have sustained his assertions respecting the want of conformability of the Hudson River slates with the Taconic. All the surveys of Michigan and Wisconsin have sustained him, though the geologists apply the later name, Huronian, to these strata. His determinations of the rocks in North Carolina have been most fully confirmed by later geologists, though some also use the word Huronian when referring to them.

In 1849 Alexander Murray an assistant on the geological survey of Canada, in the report of progress for the year 1847, described the rocks on the north side of lake Huron and many of the adjacent islands under the name of "quartz rocks and sandstones, conglomerates, slates and limestones," and correctly identified them as resting unconformably upon the older granitic and syenitic gneiss, and succeeded unconformably by the Potsdam; but he did not call them by any geological name. If he had read Emmon's "Taconic System," it is difficult to conceive why he should have hesitated in referring the rocks to that system. In the report of progress of 1856 he described these rocks under the name of the "Huronian series," which was adopted by the officers of the Canadian survey, without once mentioning the Taconic system. From that time forward authors have generally used the name Huronian, and have almost annihilated the name Taconic. The word Taconic however has priority over Huronian; it is equally appropriate, and the definition of the fossils in the upper slates at once furnishes the means of tracing it and determining it at different and distant places. The word "Huronian" is therefore a synonym for Taconic, and comprehended, as used originally by the Canadian geologists, substantially the same series of rocks, though not ascending quite so high.

A section of the so-called Huronian, but more properly the Lower Taconic, between the Mississippi and St. Mary's rivers in ascending order is as follows:

1.	Grey quartzyte..................................	500 feet.
2.	Greenish, red-weathering chloritic and epidotic slates	2000 "
3.	White quartzyte etc..............................	1000 "
4	Slate conglomerate..............................	1280 "
5.	Limestone..	300 "
6	Slate conglomerate etc..........................	3000 "

7.	Red quartzyte etc	2300 feet.
8.	Red jasper conglomerates etc	2150 "
9.	White quartzyte etc	2970 "
10.	Yellowish chert, etc	400 "
11.	White Quartzyte etc	1500 "
12.	Yellowish chert etc	200 "
13.	White quartzyte	400 "
	Total	18000 feet.

Another section adds to this one 4000 feet, and even then the maximum thickness of the series in that locality has not been reached.

Throughout the Huronian region, the whole series bears evidence of great disturbance and is frequently cut with intrusive masses of greenstone, granite, or other igneous rocks. The more recent disturbances frequently bear metalliferous veins, which give to the country its value as a mineral region. Copper and iron are the chief minerals and abound in nearly every section,—gold and silver sometimes occur. The Taconic of Michigan contains vast beds of iron ore. The ores are magnetic, red specular hematite, and soft hematite resembling the the brown hematite of other states. The magnetic and specular ores are the most prized, and usually contain from 60 to 70 per cent of iron and hardly a trace of phosphorus or sulphur. The lake Superior region is the chief locality of the world for native copper. It is so pure the aborigines manufactured it into implements. The copper-bearing rocks extend eastward along the south shore of the lake for more than forty miles, then forming a narrow belt stretch in a north-east direction, for about 100 miles, to the extremity of Keweenaw point. The copper occurs in a rock called melaphyr associated with beds of conglomerate which appear to be interstratified with it. Sometimes bands of slate separate beds of melaphyr. The native copper exists in sheets, strings and masses, and is sometimes associated with silver. In Ashland county, Wisconsin, the copper-bearing series has a thickness of more than four miles though not very rich, in ore. The Taconic area in Minnesota is large. It extends across the northern border, and forming an elbow in the northeast extends diagonally through the state to the southwest corner. Here there is a reddish metamorphic sandstone called the Sioux quartzyte, interstratified with which is a layer of red indurated clay or pipestone one foot

thick called catlinite, largely used for the manufacture of pipes. The quarry is thirty miles north of the southwest corner of the state and four miles east of the west line. The Sioux quartzyte occurs in the north-west corner of Iowa.

The geological extent of these rocks in Canada is very great. They may be traced from near lake Tematscaming, 80 miles north-west of lake Nipissing, southwestward to lake Huron, and from thence westward, on the north shore of the lake and the north shore of lake Superior, and on beyond lake of the Woods, a distance in all of about 800 miles. They pass beneath the lakes and expose a large area in the upper peninsula of Michigan, at Marquette and Menominee, and a great thickness, extending from the lowest to the highest Taconic, as first ascertained by Houghton; thence they pass into Wisconsin, exposing a large area and quite as complete a representation of the series, while another arm extends from Duluth into Minnesota. The thickness in Michigan is about four miles, but in Wisconsin, including the Copper-bearing series which is three-fourths of igneous material, the thickness is much greater, and even excluding the igneous material the thickness exceeds four miles. The upper part of the Taconic system in Wisconsin, formerly called "The Copper-bearing series," has received the unattractive name of the Keweenawan formation, from Keweenaw point, but as it is part of the Taconic system, the preferable name is the older one of the "Copper-bearing series." The rocks appear between Scoresby bay and cape Cresswell, in latitude 82° 40′ N., where Nares and Feilden called them Cape Rawson beds. In 1856 Emmons divided the system into Upper and Lower Taconic. The Canadian geologists, in 1863, placed the Upper Taconic in the Silurian system, and called it "Lower" Potsdam, which name therefore became a synonym. The only geographical names which have been used to subdivide the Upper Taconic into groups, which seem, in the present state of learning, to be worthy of retention, are in descending order, the Swanton group, the Georgia group and the St. John's group—if in fact the last is below the Georgia and therefore not a synonym. Emmons placed the Stockbridge limestone in the Lower Taconic, but it would seem from the examinations made by others that his division would have been more

clearly marked if the Stockbridge limestone had been retained in the Upper Taconic. The *Paradoxides* beds at Braintree, Mass., in Newfoundland and New Brunswick, and wherever found on the continent, belong to the Upper Taconic. The same difficulty exists in the west in separating the Upper Taconic from the overlying rocks of the Potsdam, that has led to so much discussion in the east, and the confusion is increased, by the addition of numerous synonyms—the ready weapon to to which ignorance resorts.

In 1863 G. F. Mathew named the rocks exposed at St. John's, New Brunswick, the "St. John's group." He described them as arenaceous, argillaceous and carbonaceous shales and clay slates, often sandy, with sandstone and quartzyte, having a thickness of 4500 feet, and an exposure about 30 miles long and four miles wide. He collected *Paradoxides*, *Conocephalites*, *Obelella*, *Orthis Orthisina*, *Discina*, *Hyolithes*, and *Lingula*. In 1865 he and Bailey and Hartt correlated these rocks with the slates of Vermont having *Olenellus* (*Ellipsocephalus*) *asaphoides*, and the schistose beds at Braintree, Mass., holding *Paradoxides harlani*; thus proving their "St. John's group," to be a synonym, for Emmons "Black slate" in the Upper Taconic system. Furthermore, they identified the slates with some found in Newfoundland containing *Paradoxides* and *Conocephalites*. Later, they divided the Lower Taconic of New Brunswick, which they called Huronian, into the "Coldbrook group," the "Coastal group," and the "Kingston group," and estimated the thickness as exceeding 10000 feet.

The Vermont geologists in 1861 called the Black slate, Taconic slate and Roofing slate of Emmons, the "Georgia group." The name Taconic has priority over the "St. John's group," and if the Taconic system is to be divided into groups, with geographical names, and three divisions of Emmons are to be thrown together in one group, then they must, under the laws of nomenclature, bear the name of the Georgia group. The Black slate has however been called the Swanton group, and if this name should become desirable, then the Upper Taconic would be divided into the Swanton group and the Georgia group; and their maximum thickness in Vermont exceeds two miles. This division is that adopted by Perry, who has

shown that the Potsdam sandstone rests directly upon the Swanton or Black Slate group as originally asserted by Emmons, and that both the Swanton group and the Georgia group are fossiliferous.

The Taconic rocks extend from Canada East and Maine to Georgia and Alabama, flanking almost continuously the ranges of mountains upon both the eastern and western slopes. Their thickness in New Hampshire is over four miles, and in Vermont the maximum must exceed five miles. The slate belts of York and Lancaster counties, Pa., and the rocks containing the valuable ores of nickel and copper, belong to this system. There are five extensive outcrops in North Carolina, and three or four subordinate ones. They rest unconformably upon the belts of the exposed Laurentian, and very much resemble, in their characters, the subdivisions in Vermont and New York. The largest outcrop is from 20 to 40 miles wide, and extends quite across the state. The maximum thickness exceeds five miles. There are large outcrops in Virginia, South Carolina, Georgia and Tennessee, and limited outcrops in Alabama. Gold, silver, copper, lead, iron and other valuable minerals occur in these rocks, not only in veins, fissures, and dykes, but in seams following stratification, and as parts of the sedimentary materials. In northern Georgia gold exists in seams with milky quartz, following the stratification of hornblende schists, and constituting as truly sedimentary rocks as the schists themselves do. The seams are stratified within the slaty sediments, and are of the same age as the Taconic system. These seams are so constant that they characterize the slates and schists, in the Appalachian system. They are metalliferous, and frequently auriferous or cupriferous. The magnetic, and specular iron ores also occur, with the material of the slates, as a deposit of the same age, and constituting part of the same system. This mineral wealth is so distributed that it is practically inexhaustible. The Taconic appears in Missouri, Arkansas and Texas. The iron ore districts, about Iron mountain and Pilot Knob, containing porphyry rocks, is of this age, but the granite to the east is Laurentian. The ore is found in very thick veins, in Iron and Shepard mountains and Pilot Knob. It is specular ore containing betweet 60 and 75 per cent of iron, free from sulphur

and bearing no more than a mere trace of phosphorus. The rocks appear in numerous places in the Rocky mountain ranges from Mexico to British Columbia, often exposing great geographical areas and an immense thickness, and usually metalliferous.

The genera regarded as typical of the Taconic fauna and which do not pass up into Silurian rocks, are *Paradoxides*, *Microdiscus*, *Atops*, *or Ptychoparia*, *Olenellus*, *Conocoryphe*, *Anopolenus*, *Bathynotus*, *Solenopleura*, *Acrothele*, *Salterella*, *Scenella*, *Iphidea*, *Hyolithellus*, *Archæocyathus* and *Ethmophyllum*. There are some others peculiar to these rocks, but they are either obscure or limited in their distribution. Some genera closed their existence in Silurian time, others reached the Devonian age, and some, from this remote period, as *Orthis*, *Orthisina*, *Orthoceras*, and *Leperditia*, continued to live to the Carboniferous, through *Orthoceras* reached its most remarkable development, in the Black River group, and *Orthis*, in the Hudson River. Not a single species belonging to the Upper Taconic system crossed over the line that separates it from the Potsdam group of the Lower Silurian so far as any reliable determination has thus far been made. This, supported as it is by a want of conformability, indicates a vast lapse of time between the deposit of the Upper Taconic and the commencement of the Potsdam period. The Taconic is composed of the disintegrated materials of prior Laurentian rocks, while the Potsdam represents the washings of the Laurentian and Taconic.

The Cupriferous series of the Lake region, called also the Keweenawan, Keweenian, Keweenawian and Nipigon series, is supposed to underlie nearly the whole basin of lake Superior, or an area of about 28000 square miles, and a surface area, upon the borders of the lakes and their immediate vicinity, of about 18000 square miles. This series has been divided into an upper and lower division, with an estimated maximum thickness of 15000 feet for the upper division, and 35000 feet for the lower which rests upon the slates and quartzytes of the Taconic system, the last having a variable thickness that reaches a maximum of at least 22000 feet. The Cupriferous series consists of eruptive flows and detrital rocks, with massive dikes. The region

was, in Taconic days, represented by a volcano, which has sunk beneath the waters of the lake. The flows were followed by detrital rocks representing the intervals of time between them; but these detrital rocks are composed largely of conglomerate layers and large sized pebbles, indicating strong currents of water. The flows visible upon the borders of the lakes were forced through fissures by volcanic energies. The copper, which occurs in the conglomerates, amygdaloids, epidote veins and otherwise, is supposed to have been precipitated from water holding it in solution, or leached from detrital rocks where it was originally deposited in a sulphureted form. R. D. Irving, who has studied closely the copper bearing rocks of this region, says the explorer for transverse veins should bear in mind that epidote, prehnite and chlorite are favorite associates of copper, while laumonitic veins and those bearing a predominating quantity of calcite are not so rich; that a wide vein in amygdaloidal or other soft rocks will pinch to a mere seam, within the massive and compact layers; and in sandstone and conglomerate deposits the valuable belts have been found where the conglomerate is overlaid with trap, or in sandstone very rich in basic detritus. Any of the conglomerate seams from Keweenaw point to Minnesota may be cupriferous. All of the upper division of the series is non-cupriferous, except the Nonesuch sandstone belt in the Porcupine mountains; and all the belts and areas of acid rocks, such as the central area of the Porcupine mountains, and the great spread of red rock, in the Brulé lake country in Minnesota, and all belts and areas of coarse-grained basic rocks, such as the great area of coarse gabbro in the Bad river region in Wisconsin, and the similar area which occupies the belt of country from Duluth to Brulé lake, are also non-cupriferous. The slates and quartzytes of the Taconic system which lie below the Cupriferous series on the north shore of lake Superior, have been called the Animikie group. About three-fourths of the great thickness of the rocks is referred to Volcanic overflows and does not therefore, belong to the geological column, the whole of which is the result of sedimentary deposition.

The vast extent and great thickness of the rocks, resting on the granite and gneiss and followed by the Potsdam sandstone,

were first made known by Ebenezer Emmons. He described their stratigrapical and mineral characters as carefully and fully as any one was capable of doing in his day, and he furnished the palæontological evidence by which they might be determined, and gave to them a geographical name according to the requirements of nomenclature. Every species illustrated by him is a valid species to-day, and none of them occur in higher rocks. The generic name *Ellipsocephalus* was preoccupied and hence gave way to the later name *Olenellus*, but *Olenellus asaphoides* is characteristic of the Upper Taconic in the region explored by Emmons, and the genus is characteristic elsewhere. His *Atops trilineatus* is characteristic, though complaint has been entered against the name *Atops* because he did not define it, and some use therefore the later generic name *Ptychoparia*. He illustrated, and named the fossil for the purpose of showing the fauna of the rocks, and whether his generic name shall stand or that of Corda be substituted, is of no importance, so far as his labors went, in establishing the Taconic system.

EDITORIAL COMMENT.

THE RIGHTS OF INTELLIGENCE UNDER PAID SERVICE.

Again we hear the sound of complaint in behalf of uncredited and unhonored work performed under contract, for a pecuniary consideration. It is a familiar sound. A bright and industrious young man enters into an agreement with an employer to perform a certain service involving more or less learning, intelligence and administrative ability. It may embrace work in original scientific investigation. The engagement runs on for years by mutual consent, and the employed acquires a high degree of ability for original research. The results of his labors, however, appear under the name of his employer; and the immediate investigator's name remains unannounced to the public —at least, uncredited for the work done. Such instances have fallen under our observation from the fields of general geology, palæontology, zoölogy and botany; and the paid investigator

has not in all cases, been a young man. Whatever the field and whatever the condition in life of the person engaging his services for hire, the ethical principles involved are the same. They are the common principles of ethics; they are very obvious, and disentangled from their environment, are very simple.

The case is so simple that we venture to state elemental principles which must regulate correct action.

Every agreement made is binding, according to its terms, against both the parties; and neither party has the right to terminate it or alter its provisions during the period specified in the agreement. If no period is specified, the agreement may be terminated at the will of either party; and if neither party signifies his desire to terminate the agreement, both continue to be bound by it. The agreement may prove onerous to one of the parties. It may become increasingly onerous; but unless the stipulated period of its continuance has been completed, he has no remedy but an appeal to the generosity of the other party. This supposes, of course, that the other party continues to execute faithfully all the stipulations to which he agreed.

In an agreement to render scientific service for a money consideration, accessory conditions come into view, which constitute a distinct class of contracts; but these conditions do not qualify the ethical principles involved in all contracts. They become, rather, an occasion for the introduction of special stipulations in the form of the contract. Whether introduced or not, the moral and legal obligations created by it exist under the simple principles just stated.

The most important accessory condition in a contract for scientific service is the usual knowledge and intelligence required, and the increased value of their service with increase of knowledge and experience. Plainly, if the stipulations of the contract do not provide for special compensation in some form, in addition to the pecuniary consideration, the employé has no claim on his employer, beyond the stipulations. If they do not provide for increase of compensation, either in money or reputation or some other form, as the value of the employé's services increases with his experience, the latter still, has no claim beyond his agreement. The employer has discharged his duty, if

he has kept the stipulations of the contract to the end of the specified period.

The most plausible ground of complaint against an employer is the neglect to make public acknowledgment of results produced under the contract by the employé, in cases where the terms of the contract do not expressly provide for such acknowledgement. Where alternative courses are open to the employer, the employé should see beforehand that the contract provide for one course or the other. If he does not, neither party has liberty to elect arbitrarily which coursc shall be pursued. Usage must control. If the contract does not specify that the employé, in addition to his material recompense, shall be publicly credited for his work, then the employer is not at liberty to hold arbitrarily that no such credit shall be given; and the employe is not at liberty to hold arbitrarily that it shall be given. The contract must be construed in the light of existing usage. But if usage be divided, either party may insist on the usage preferred by him; but neither can have redress if his view is not accepted by the other. However, as the giving or witholding of public credit is necessarily the act of the employer, his decision on the usage to be followed will necessarily prevail, and the employé has no redress.

Does any usage exist then, in reference to the accordance of public credit for work done, in additional to the material recompense? The director of a geological survey is himself the employé of the State The results of his investigations are published under his own name. It has never been known that the name of the State was subscribed to the results, to the exclusion of that of the director. In this case, however, the agency of the State is a minimum, and does not embrace any part of the intellectual effort represented in the result.

The director of a geological survey generally employs assistants. These receive pay for their services and also credit for the professional work personally performed. The Director of the United States survey surrenders all claim to the credit for results attained. The Chiefs of Divisions also, divide honors with their subordinates in the proportion of results attained severally. Every worker receives his pay, and such reputation as he can make in addition. Not less, where the work of a

division is chiefly in the laboratory or office—as in researches in palæontological collections made by others. Every worker becomes responsible for what he accomplishes. Even the collector stands credited in the published reports. Such seems to be the usage in the conduct of public investigations.

Naturally, the same usage might be expected to prevail in-investigation under private auspices. But it cannot be said that such is the case. There is an obvious reason for the difference. The pecuniary costs of field-work and investigation are often very considerable. When the general public defray the costs, no individual's contribution is important; and no individual acquires any claim antecedent to or collateral with that of the explorer or investigator. But when the expenses are defrayed by one individual, he acquires a lien on all the results worked out under his direction; and can dispose of his rights according to his own pleasure. If he can get investigation done for a salary, that is his right; but, if he is willing also, to accord some amount of public credit to his paid investigator, that is under his discretion. There is good reason for his not disbursing to others all credits for results produced. That he has not personally produced all of them is due simply to the fact he has yielded to others so much opportunity to become experts and acquire standing.

Where investigations are carried on at the cost of a public museum or institution the results sustain relations analogous to those accruing from a public survey. No individual can assert a prior lien on the ground of antecedent expenses. By established usage in public work, and by a rational courtesy, the assistant in such case is entitled to due acknowledgement, even in cases where previous agreement does not stipulate for it.

Speaking now exclusively of cases in which the employé engages in paid investigation under private auspices, and without stipulation for any compensation other than the material salary, it appears to us that the employer might even to his own advantage, make such public recognition of the work of the employé as to enable him to feel that he is creating honorable reputation in common with similar workers on public enterprises. Still, he should feel that his employer has borne great personal burdens, and should not expect him to cede all honor and reputation to those whose opportunities he has created.

Every subordinate worker under private auspices, without pledge for share in the reputation earned, may still congratulate himself on the opportunity for acquiring exceptional skill, and laying the foundations of personal reputation, whenever he shall become free from the restraints of his personal obligations. If however, while such eventuality is pending, health fails, or death intervenes, the case becomes deeply sad; but the disappointment can only be regarded as an incident of human fortune. It is not an occasion for incrimination of the employer, unless it appears that he failed in the discharge of some portion of his agreement with the employed. It furnishes, however, a a fit opportunity to exercise his magnaminity in according to his coadjutor and helper a posthumous reputation to such an extent as it may be done in justice to himself.

The discussion of this subject would be incomplete, should we fail to point the moral. Every man, young or old, who engages in the paid service of an employer conducting researches at his own cost, should enter into a written agreement specifying to what extent he will be entitled to public acknowledgement for scientific results attained by his personal efforts. This precaution should also be taken if the work is to be done under the auspices of a public museum. If under the auspices of a public survey, credit may be expected and demanded under the law of prevailing usage.

THE USE OF THE TERMINATION YTE FOR NAMES OF ROCKS.

The use of the termination "yte" in THE AMERICAN GEOLOGIST has occasioned some inquiries. As we expect the journal to be read by many who are not professional geologists, a word of explanation is here offered. In the fifth edition of his *System of Mineralogy* (1868), *Introduction*, p. XXXIV, professor James D. Dana introduced the following paragraphs:

"It has appeared desirable that the names of rocks should have some difference of form from those of minerals. To secure this end, the author has written the final syllable *ite* of such names with a *y*; thus Diorite, Eurite, Tonalite, etc., are written Dioryte, Euryte, Tonalyte. The *y* is already in the

name Trachyte. The author has allowed Granite, and Syenite to remain as they are ordinarily written, since they are familiar names in common as well as scientific literature."

In the third edition of his *Manual of Geology* (1880) page 67, the same change is formally adopted into that work. It has not however been sanctioned by the usage of geologists either American or European. It is not employed in E. S. Dana's *Test Book of Mineralogy* (3rd ed., 1880); and every writer in the *American Journal of Science* (controlled by J. D. Dana) is allowed to employ his own orthography. The Minnesota geological survey, however, has uniformly employed the new spelling, and the managing editor has introduced it into the GEOLOGIST. With any manifest tendency to adopt the spelling proposed by Dana, it might be desirable to expedite the result by promoting the multiplication of examples of approval. For the present however, the final verdict of geologists cannot be anticipated with any probability.

TO ALL AMERICAN GEOLOGISTS.

The International Geological Congress at Bologna determined to put to a practical test the best of the many schemes presented to it for unifying the colors in geological map-making, by selecting some large area which should be as well known as possible to the largest number of geologists, and which should include the greatest number of cartographical difficulties. Europe was naturally the area chosen. Not only is there in that continent a greater number of geologists to the square kilometer than in any other, but from the very fact that they belong to various different and unhappily sometimes antagonistic nationalities, it was shrewdly thought that if any scheme can pass the order of acceptance there, its chances else-where are very good. As to the inherent puzzles of structure, whilst it cannot be said that Europe has the monopoly of them or can even furnish the most difficult problems for solution, yet what there are have been so long and so zealously discussed by the masters in geology that it atones for the want of natural intricacies by having secured a large amount of artificial ones. The area is therefore well chosen.

The Congress decided to accept as a base for the map one specially to be prepared by Prof. Kiepert of Berlin, which is to include all the latest geographical data published and unpublished. As a geographical map alone it will therefore have the highest value. It is to be printed in 49 separate sheets (7 in width and 7 in hight) of which each is to be about

48 centimeters (say 19 inches) high by 53 centimeters (say 21 inches) wide. The map if mounted as a whole will cover a space 11 feet high by 12 feet wide, and its scale will be 1 : 1,500,000. To pay for this map the Congress has received appropriations 10,000 francs each from the following "large countries" which are considered as "subscribers," and to each of which 100 copies of the map when completed will be sent, viz.: France, Spain, Austro-Hungary, Russia, Scandinavia, Germany, Great Britain and Wales.

The "other countries" viz: Belgium, Holland, Denmark, Switzerland Portugal and Roumania are to divide amongst themselves 100 copies and jointly to become a subscriber.

It occured to the American Committee that inasmuch as the object of the enterprize was less to make a map of Europe than to settle a general and far-reaching principle, the United States had as much interest in it as European countries, and should certainly have some of the maps. The only question to settle was, whether it shonld be ranked with the "large countries" or come in among the little ones as part of a subscriber. On consulting the map of the United States, the annual reviews of geological papers published, and the lists of geologists in the United States, the Committee was induced—let us hope not too rashly—to apply to the map committee for the recognition of its country as a large one capable of assimilating 100 entire geological maps. Patriotic Americans will not blame the committee for deciding thus, yet it may be stated that several thousand circulars setting forth these facts sent out by mail during the last three years to all the institutions of learning and scientific men whose addresses could be obtained either from the exchange lists of the U. S. Geol. Survey, Cassino's Directory and the published members of Section E., A. A. A. S.. have thus far resulted in disposing of only seventy-eight copies. In both the circulars and in innumerable articles contributed by the writer to scientific journals such as the Am. Journ. of Sci.; Science, Journal of the Franklin Institute, American Naturalist, the daily papers, and the published proceedings of the Am. Inst. of Mining Engineers, of the A. A. A. S., the Am. Phil. Soc. &c. &c., it has been again and again stated that the cost of the map to every subscriber will be 100 francs plus a few sous for transportation if delivered in Europe, but for American subscribers the sum has been fixed at twenty-one dollars ($21.00) to cover freight &c. for all institutions entitled to receive educational publications free of duty. This sum will pay all expenses to the express or freight office nearest to such institution.

Individuals must pay in addition to this the duty which as nearly as it can be estimated now will amount to five dollars. (See the letters of Mr. Cadwalader, Collector of the port of Philadelphia, appended.) The cost of the map to an individual will hence be $26.00, all expenses paid.

This will be the same price which will be charged to individuals in Europe with one dollar additional to pay all costs to the final destination of the map. But as a compensation, the individuals who help the Com-

mittee to complete the requisite number of subscribers will receive their copies before the sale is opened to the general public.

The following is a list of subscriptions sent to the undersigned up to date.

It should be understood that no money subscriptions are asked for at this time. As soon as I am notified that the map is ready I shall notify the subscribers who will then greatly oblige me by promptly remitting the amount above mentioned.

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Of the above 73 subscribers 15 are from Pennsylvania (12 from Philadelphia); 14 from New York; 6 from Massachusetts. 3 each from Washington, Ohio, Michigan, California, Connecticut, and Canada; 2 each from Kansas, Indiana, and Alabama; and 1 each from Arkansas, Colorado, Iowa, Illinois, Kentucky, Maryland, Missouri, Nebraska, North Carolina, New Jersey, New Hampshire, Wisconsin, and Virginia.

Not a single copy of this map which is both intrinsically and historically of great value, will find its way to the great states of Maine, Vermont, Rhode Island, Delaware, South Carolina, Georgia, Florida, Mississippi, Tennessee, West Virginia, Louisiana, Minnesota, Texas, Nevada, not to speak of the territories, many of which are well advanced in methods of teaching.

The writer appeals again not only to American geologists but to educators everywhere to assist him in placing the remaining 22 copies of this map. He is not informed when the map will be ready for distribution but it would seem natural that it would be prepared for Congress next September if a possibility of this exists. He asks that the names of subscribers be sent to him at the address below.

The Collector's letters are herewith appended:

CUSTOM HOUSE, PHILADELPHIA, PA.,
COLLECTOR'S OFFICE, March 10th, 1887.

DR. PERSIFOR FRAZER, *Secretary American Committee, etc.*

DEAR SIR: Referring to your communications of 24th, ultimo and 9th instant respectively, in relation to the question of admitting free of duty the International Geological Map of Europe for the use of certain subscribing educational and scientific institutions in the United States, I beg leave to state that the clause in the tariff which would admit the maps or charts described by you to free entry is as follows: "Books, maps and charts specially imported, not more than two copies in any one invoice, in good faith; for the use of any society incorporated or estab-

lished for philosophical, literary or religious purposes, or for the encouragement of the fine arts, or for the use or by order of any college, academy, school or seminary of learning in the United States." In order to have the benefit of this provision it is necessary for the institution to file with the Collector "a certified copy of the certificate of incorporation, and other proof of organization, showing that the institution is of the character and established for the purposes mentioned in said provision of law" (Art. 312 Regs.). In addition thereto an affidavit of the proper officer of the institution is required according to the form on blank herewith enclosed. [Free Entry Blank, Cat. No. 611, enclosed.]

You will observe that there are two essential pre-requisites necessary in order to bring the institution within the benefits of the provisions aforesaid, viz.: That it should be such an institution as is described therein, and that the map should be *specially imported* by its order and for its sole use.

Every case must be disposed of on its merits, as it arises and no advice of a general character can be given in advance further than can be gathered in a general way from the law and regulations above stated.

I may say, however, from my knowledge of them that most—if not all—of the institutions named by you would be entitled to the privilege. The individuals you name are, of course, not entitled to it.

It is customary for the principal officers of United States institutions to make application, through their Departments, to the Secretary of the Treasury for the free admission of articles for public use; hence, if this course is pursued by the Geological Survey and Military Academy, and the necessary authority is received by the Collector from the Department, the maps will be admitted free for those institutions without further requirement.

If all the regulations herein referred to were complied with, there would probably be no objection to your Committee acting as agent for the institutions in making the importations.

Most of the institutions specified have, probably, heretofore availed themselves of the benefits of the foregoing provision for the free importation of books, maps, charts and scientific apparatus and are, consequently, familiar with its requirements.

Very respectfully,
JOHN CADWALADER,
Collector.

CUSTOM HOUSE, PHILADELPHIA, PA.,
COLLECTOR'S OFFICE, March 22, 1887.

DR. PERSIFOR FRAZER, Philadelphia.

DEAR SIR: Referring to your letter of 21st inst., I have to inform you that as the rate of duty on maps is 25 per cent. at ad valorem, the *amount* of duty to be assessed will depend on their market value at the time and place of exportation to the United States, which value is determined by the appraiser upon the examination of the articles. Five dollars was specified, as you stated the value of the maps to be $20 each.

Very respectfully,
JOHN CADWALADER,
Collector.

PERSIFOR FRAZER,
201 South 5th St., Philadelphia, Pa.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the structure and affinities of the genus Parkeria Carp. By H. ALLEYNE NICHOLSON (Ann. and Mag. of Nat. Hist., Jan., 1888). This paper, in common with nearly all of Dr. Nicholson's works, is evidently the result of painstaking and sytematic inquiry, being a careful record of observations made during the progress of a minute investigation into the structure of the peculiar genus *Parkeria*. His observations are founded upon an abundance of good material and extensive series of thin sections mainly prepared by himself.

The author begins his paper with a condensed history of the genus. From this we learn that *Parkeria* was originally described by Dr. W. B. Carpenter in 1870 (Phil. Trans., vol. clix, p. 721), and that the genus was regarded by this eminent authority as belonging to the arenaceous foraminifera. In 1876 and 1877 the structure of the genus was investigated by Mr. Carter, who came to the conclusion that the skeleton was aot arenaceous and that the genus should be referred to the Hydractiniidæ. Mr. Carter's views have, in the main, been accepted by subsequent writers, such as Steinmann and Zittel, and are now concurred in by Dr. Nicholson.

The ordinary form of *Parkeria* presents itself in the shape of spherical bodies, varying in diameter from less than half an inch to about two inches. Most of the specimens must have been entirely free in the adult condition, but some at any rate, commenced growth upon some foreign body. The surface of unworn examples generally exhibits rounded or elongated elevations; in other cases it may present an alveolar or honeycombed aspect. Rough fractures show that the skeleton is composed of numerous cylindrical columns ("radial pillars") which traverse the fossil in a radial manner from the center to its circumference, and are united at more or less regular intervals by imperfect concentric layers, separated from one another by concentrically arranged interspaces ("chamberlets"). These interspaces, or rather each successive tier of them, represents what was at one time the surface of the organism.

As regards the chemical constitution of the fossil skeleton, great differences are noticed in large series of specimens, in some it being composed of carbonate of lime, with the chambers of the fossil occupied by calcite or by an infilling of the matrix in which the specimen was originally imbedded. In the majority of cases the skeleton is more or less extensively composed of phosphate of lime with the chambers occupied, throughout or in part, by phosphatic infilling, whilc in a third group of specimens in which the skeleton is also largely composed of phosphate of lime, the central portion or the whole of the fossil has its chambers empty.

The question, what was the original composition of the skeleton *Parkeria* is carefully considered. Carpenter's view, that it was composed

of a small proportion of sand grains cemented together by a mixture of phosphate and carbonate of lime (a condition best shown in the third group of specimens above mentioned) is shown by good reasoning to be erroneous; while Carter's view, that the skeleton may have been originally chitinous in nature, is likewise thrown aside to give place to his own view. This is, that the skeleton of *Parkeria*, like that of the *Stromatoporoids*, "was originally composed of carbonate of lime, and that phosphatization, when it has occurred at all, has been the result of secondary processes which have operated subsequently to fossilization."

The author next works out the minute structure of the organism in a very satisfactory manner, showing by good illustrations, that the radial pillars and the connecting concentric lamellæ are composed of innumerable, minute, simple, untabulated, cylindrical or polygonal tubuli, having a radial disposition. These tubuli are separated by thin, porous walls, allowing free communication between their cavities. The general cancellated tissue formed by them is regarded as cœnosarcal in its origin, and compared with the canaliculated cœnosarcal tissue of *Distichopora*, *Allopora*, *Pliobothrus*, etc., and with the clathrate tissue of the Hydractiniidæ.

A coarser kind of cancellated tissue is commonly developed in thin concentric bands at periodic intervals, separating thick strata of the ordinary skeletal tissue. It consists of wide, irregular cells or tubuli, united by coarse reticulated tissue. This the author is disposed to regard as representing a periodic development of reproductive zooids, and to compare with the periodic production of "ampullæ" in the *Stylasterids*.

Certain more or less numerous, large, oval or circular tubes, averaging 0.15 mm. in diameter, are supposed to have contained zooids, and to correspond to the gastropores and dactylopores of the Hydrocorallines.

Lastly the author compares the form under discussion with some recent and many extinct organisms, showing its relations to the *Stromatoporoids*, the curious *Mitcheldeania*, *Syringosphæra*, and other forms.

With regard to the systematic position of *Parkeria*, he concludes that "there can be little hesitation in accepting Mr. Carter's reference of the genus to the Hydrozoa. All the known facts as to the chemical constitution, mode of growth, and general structure of the cœnosteum, no less than the minute structure of the skeleton-fibre, point unequivocally in this direction. With regard to the precise place which *Parkeria* should occupy in the series of the Hydrozoa, it may be regarded as intermediate between the Hydrocorallines and the Hydractiniidæ, but with nearer relationships to the latter than to the former. In the minute structure of the skeletal tissue *Parkeria* most closely resembles the Hydrocorallines; but in the general arrangement of its parts, and more particularly in its mode of growth by the production of successive concentric lamellæ separated by rows of chamberlets, it approaches most nearly to the Hydractiniidæ, with which group the genus may in the meanwhile be ranked."

A brief narrative of the Journeys of David Thompson. By J. B. TYRRELL, of the geological survey of Canada (Proc. of the Can. Inst., March, 1888).

This is an important record of early geographical exploration. It brings to daylight a large amount of itinerary which has been buried hitherto in the archives of the Crown Land Department of Ontario. David Thompson crossed Minnesota in 1798, and discovered Turtle lake which, like Beltrami twenty-five years later, he regarded as the source of the Mississippi. He also reached the Missouri river, and the Columbia which he descended to its mouth July, 15th, 1811.

Contributions to the paleontology of Brazil, comprising descriptions of Cretaceous invertebrate fossils. By CHARLES A. WHITE. 4to, 273 pp. 28 plates. (From vol. vii of Archivos do Museu Nacional do Rio de Janeiro, 1887.)

This large document, which has a parallel Portuguese translation by Mr. Orville A. Derby, reflects credit on both North and South America, and is a renewed proof of the friendly interest of the Brazilian Emperor in natural science. It is based on collections made by the geological survey of Brazil under the late Prof. Charles Fred Hartt, but is issued by Mr. Orville A. Derby, director of the geological section of the Brazilian National museum, who was appointed to preserve the results of the survey after the lamented death of professor Hartt. The letterpress was done at Rio Janeiro, but the plates were lithographed at Philadelphia by Sinclair.

The work describes 57 new species of conchifers, 77 of gasteropoda, 8 of cephalopoda, 5 of mollusca and 12 of echinoderma. They are all referred to the Cretaceous (Neocomian) age, although they exhibit a composite character, partaking of the Jurassic and of the Tertiary. Three new genera of gasteropods and one of echinoids, are proposed. The former, *Orvillia, Cylindritella, Cypræactæon* are proposed by Dr. White, and the other *Heteropodia*, by Prof. P. de Loriol.

Some noteworthy facts are brought out concerning the relation of this Brazilian fauna with the Cretaceous fauna of other parts of the world. It is shown that this fauna has surprisingly little in common with the Cretaceous of North America; somewhat more with that of Europe; while its affinity with the Cretaceous fauna of southern India is conspicuously observable. Five species are identified with Indian forms as published by Stoliczka; and three or four others are either identical, or very closely allied, species.

One species of *Aucella* is described, which is only the second discovery of this genus in the southern hemisphere; the other being *A. plicata* Zittel, from New England.

A small collection of fossils from the Bahia group further from the coast are fresh-water types, and have a recent aspect, illustrating, as Dr. White remarks, the fact that living fresh-water types have come down to us from remote geological periods almost unchanged. Prof. Cope has examined the vertebrate remains found in these Cretaceous beds, and has referred them to the Fox Hills group of the western United States, and those of the fresh-water Bahia group to the Laramie. Mr. Derby has given a tabulated grouping and discus-

sion of the various species, referred to the different provinces, showing an extensive Cretaceous formation along the Atlantic coast of South America.

Preliminary report on sea-coast swamps of the eastern United States. By N. S. SHALER. Pages 353-398. (Accompanying the sixth annual report of the director of the U. S. geological survey.)

The most noteworthy features of our Atlantic coast from New Hampshire southward are its beaches lying commonly one to five miles outside the shore of the mainland, and its salt marshes or swamps which are formed in the shallow water thus enclosed. They remind one of the barrier coral reefs of tropical shores, and the author finds in them an almost equally interesting field of geological study.

Where deep water reaches to the coast and fills its indentations, as along the hilly and partly mountainous coast of Maine, these sheltering beaches are wanting or very scantily developed, and swamp deposits are limited to estuaries and narrow margins of the most shallow and protected bays and inlets. In marked contrast with this, on the south side of Long Island and from New Jersey to Florida, the very gentle slope of the coastal plain in its descent beneath the sea-level causes the formation of the beach to take place several miles off shore, where it extends nearly continuously along this distance of a thousand miles. Along the portions of the coast most favorable for its formation it is interrupted only by gaps which are maintained by the outflow from rivers and the flow and ebb of tides.

On a moderately hilly coast, like that of Massachusetts, when the sea has been shallowed by the accumulation of sediment so that the space between the capes of a bay is brought within about twenty feet of the surface at the time of low tide, the conditions are favorable for the closure of the inlet by a barrier beach. In heavy storms the waves mount too high to pass over the shallow without breaking. The forward motion of the wave is arrested, aud the detritus which it was urging forward falls upon the bottom, until gradually a ridge of beach gravel and sand is built up to the level of high water. Protected behind the beach, the swamp deposits are formed chiefly of the fine sediments brought in by the tides. The dense growth of eel-grass covering the bottom favors this deposition of sea-mud up to the level of low tide, and forms the lowest bed of the swamp. Between this marine vegetation and that of the shores a zone of mud flats, laid bare at low tide, is built up more slowly until it reaches sufficient light to permit the growth of the marsh-grass and other shore vegetation which can endure at most only a submergence of a few feet at high tide. These form respectively the middle and upper beds of the sea-coast swamp, the surface of which is thus raised nearly to the level of the highest tides and then supplies crops of marsh hay.

The tide flows in and out by very irregularly winding and branching channels, and there is hardly an acre that is without one of these waterways. Its steep sides and tortuous course show its constant battle with

the encroaching plants, which grow with the most vigor near its banks. Because these channels obstructed the harvesting of the hay crop, nearly all the sea-coast swamps of New England have been ditched so that the tide now finds it entrance and egress by a system of artficial parallel channels a few rods apart; and in consequence the natural water-courses have often disappeared, their beds being rapidly filled by mud and the rank marsh vegetation.

Professor Shaler states that the aggregate area of salt-marsh lands capable of being reclaimed from the sea by dikes and brought under cultivation exceeds 200,000 acres for that portion of the Atlantic coast lying between Portland and New York. The present agricultural value of these lands for their product of hay does not exceed about $10 per acre: but under cultivation like the similar lands gained from the sea in Holland and other northern parts of Europe they will have a value of not less than $200 per acre, amounting in total to at least $40,000,000, and it is estimated that the cost of reclaiming these acres and reducing them to cultivation should not exceed the fifth of this sum. They are unsurpassed in fertility as market-garden soils and are practically inexhaustible. South of the New England shore the marsh area is much more extensive than in that region, and it is probable that the improvable marshes of our entire eastern coast amount to at least 3,000,000 acres.

The limited tracts of sea-coast swamps are described in detail, with maps, namely, the Plum Island marshes which extend Southward from the north of the Merrimac river, and the diked lands of Green Harbor river in Marshfield, Mass. A catalogue of the salt marshes on the coast of New England south from Casco bay and of Long Island is also given, with their approximate areas derived from measurement on the Coast Survey charts.

Postglacial marine deposits containing shells of the Leda, with other genera that inhabit the northern circumpolar seas and extend south to temperate latitudes, occur in Maine up to 200 feet or more above the present sea-level, showing that at the close of the glacial period the ocean there covered more of the land than now. It therefore seems very remarkable that no evidence of elevated marshes or beaches has been found in that region; and their absence proves that this northward postglacial submergence was very brief, and that the sea very quickly attained its present altitude, pausing at no time long enough to develop the characteristic features of a shore line.

On nepheline rocks in Brazil, with special reference to the association of phonolite and foyaite. By ORVILLE A. DERBY. (From the Quart. Jour. Geol. Soc. London, August, 1887). The author gives descriptions of the field-appearances of the rock masses of foyayte and phonolyte. He concludes that these indicate (1) the substantial identity, as regards mode of occurrence and geological age of the Caldas phonolytes; and foyaytes (2) the connection of the latter, through the phonolytes, with a typical volcanic series containing both deep-seated and aerial types of deposits; (3) the equal if not greater, antiquity of the leucite rocks as compared with the

nepheline rocks, whether felsitic, as phonolyte, or granitic, as foyayte, and (4) the probable Palæozoic age of the whole eruptive series.

The Geological Magazine for February. In the February number of the *Geological Magazine* Sir. Wm. Dawson notes several new facts regarding Eozoön. He says that some recently found specimens show that it had a definite form which was funnel, or top-shaped; that it had no *theca* above or below, and that the laminæ coalesce at the margin. These laminæ are thickest at the base and become thinner and confused above. Sir Wm. Dawson is convinced that the forms which he described under the name of Archæosphærinæ are only these upper layers of Eozoön.

Some cut specimens of Eozoön show, he states, a tubular structure to which he applies the term "oscula" apparently suggested by some resemblance to the "oscula" of sponges. He also draws attention to the fact that some of the Laurentian limestones contain abundant fragments of Eozoön, showing its peculiar granulated structure, but not its canals.

Sir William then suggests that certain bodies found in the Laurentian of the Ottawa district, and the Cryptozoön of Hall and Winchell from New York and Minnesota, may be related to the Eozoön of the Laurentian limestones.

In conclusion he urges, against the views of Mr. Julian and others, who maintain the mineral nature of Eozoön, the following objections.

1. Laminated minerals have simple laminæ; those of Eozoön are connected.

2. Laminated minerals are wholly crystalline; Eozoön has tubercles and "oscula."

3. Is it probable that pyroxene, serpentine, loganite, dolomite and earthy limestone should all assume the same form?

4. Eozoön often occurs away from the nodules and bands of pyroxene, etc., in the limestone.

5. Eozoön does not resemble any banded rocks known in the Laurentian series.

Prof. Bonney contributes the results of some experiments, and observations on the rounding of pebbles by rivers and streams chiefly in the Alps. The process is of course most rapid when the motion is swiftest, that is in the higher parts of their courses. He lays down the following principles which are fully in accord with Daubrée's previous conclusions:

1. The time of rounding a stone depends upon its nature.

1. Stones are rounded most quickly where the descent is rapid and but slowly when the stream is only just able to move them.

3. The process is most rapid at first. "Perhaps we may venture to say as a rough standard of comparison that the effect of a thousand feet of rapid descent is equivalent to that of the more leisurely traverse of at least twenty miles, so that fairly well rounded pebbles of a rock with hardness not exceeding 6 signify either a rapid descent of 3,000 feet or a journey at less speed of 60 miles."

Col. McMahon argues in reply to Mr. R. D. Oldham, that the foliation of granite, as in the Himalayes, is due to pressure acting on the intruded granite *before* it had become completely solidified and not to the metamorphism due to pressure exerted on a cooled and solid rock.

Messrs. Cornish and Kendall, following out a suggestion of Sorby's, detail the results of a series of experiments by which they have proved that shells composed of the aragonite form of carbonate of lime are much more easily dissolved by carbonic acid water than shells composed of calcite. They suspended two fossil shells *Pecten opercularis* (calcite) and *Pectemculus glycimeris* (aragonite) in a solution of carbonic acid and found that the latter lost weight much more rapidly than the former. The experiment was continued until the aragonite shell literally fell to pieces. That this change was due to structure rather than to the nature of the minerals was shown by performing the experiment with *powdered* calc-spar and with *powdered* shells, in neither of which cases was any difference observed in the rate of solution. The structure of shells composed of aragonite is, they state, looser than that of shells composed of calcite.

The authors concluded by pointing out how these facts may account for the disappearance of fossils composed of aragonite from rocks in which shells composed of calcite still remain, and quote several instances in support of this opinion.

PERSONAL AND SCIENTIFIC NEWS.

MEXICO AND THE PACIFIC SLOPE. Prof. A. E. Foote of 1223 Belmont Ave. Philadelphia, Pa., who has recently returned from a nine months stay in Europe, where he spent much time in Cornwall and Hungary, will soon start for a third trip through Mexico and the Pacific states returning by way of the Rocky Mountain region.

A knowledge of the Spanish language and a considerable experience in Mexican mines will render his trip especially serviceable to those desiring information of these regions.

PROF. J. P. LESLEY IS ENGAGED ON A SUMMARY of the results of the Second Geological Survey of Pennsylvania which it is hoped will appear in no very long time. Such a work is exceedingly desirable in order to bring within the reach of working geologists the mass of material accumulated and at present almost buried in the more than fifty volumes of which the publications of this survey consist. The work will be handsomely illustrated, with engravings, by various processes, of the principal fossils discovered during the prosecution of the work, and will be received with pleasure by geologists.

PROF. MARSH GIVES A SUMMARY in the London Geological Magazine of his description of Stegosaurus, a Jurassic, aquatic reptile belonging to the Dinosaurians and allied to the ornithopoda, a group intermediate between birds and true reptiles. This animal was not large and was covered with bony plates, and its tail was armed with spines formidable for its size, ranged in pairs along the tail, and probably used in the same manner as are those of the existing sting-ray.

THE SWINDLING NATURALIST. I take pleasure in informing you that the "Swindling Naturalist" has finally gotten his just deserts. Six weeks ago, he stole from the University of Cincinnati a number of microscopic objectives, and made good his escape. Recognizing the importance of securing him, our city detectives were put on his track. He was traced through Indiana and Kentucky to Nashville, Tenn., and finally apprehended. On being returned to this city and indicted for grand larceny, he pleaded guilty, and has been sentenced to spend five years in the Ohio penitentiary. The scientific world is, for a time, well rid of him. He passed here under the name O. L. Syrski, and (after capture) freely admitted his identity with the "Swindling Geologist" of numerous aliases.

If you can let me know the name of the owner of the Chenu's *Conchyliologie* and the Wales objective, mentioned on page 68 of the first number of the GEOLOGIST, I may be able to furnish information which will lead to the recovery of the property.

Yours respectfully,
CHAS. H. GILBERT,
Univ. of Cin.

Cincinnati, O., March 5, 1888.

[NOTE. This man has been engaged in these petty thefts for five or six years, and has been published and described repeatedly by the press of the country. He was apprehended about two years ago in Wisconsin, and served six months imprisonment in the Elkhorn jail, but he immediately resumed his old methods of obtaining a livelihood. Such rascals are not peculiar to America. About six months since Mr. Quaritch, of London, advertised for the apprehension of a thief, supposed to have come from Germany who had stolen from his stock of books. Ed.]

THE SECRETARY OF THE AMERICAN COMMITTEE of the International Congress of Geologists has issued a call for a meeting of the committee at Murray Hill hotel, New York, at noon, Monday, April 2nd., the object being to receive the delayed reports and to complete the work preliminary to the next Congress which meets in London on the 17th of next September.

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A NEW GENUS OF CRINOIDS FROM THE NIAGARA GROUP.

BY S. A. MILLER.

SIPHONOCRINUS n. gen.

The species belonging to this genus, so far as known, are very large, rough or irregular and robust. They are all casts, with the exception of one or two specimens preserving part of the plates, with the surface markings destroyed, and the specimen figured by Hall taken from a gutta-percha cast in the natural mold, and figured on plate 10 of the 20th Rep. N. Y. Mus. Nat. Hist., under the name of *Glyptocrinus nobilis*, which shows the external ridges and nodes of ornamentation on some of the plates.

Basals three, pentagonal, except as affected by the perforation at the end of the column. They are rather small and, therefore, may have been nearly covered by the column.

Primary radials 3x5; the first plates large, heptagonal and hexagonal, about as wide as high; the second hexagonal, longer than wide, and nearly as large as the first; third radials nearly as large as the first, about as wide as high and supporting upon the upper sloping sides the secondary radials.

The first interradials approximate, in size, the first primary radials and rest upon the upper sloping sides of the latter. They are each succeeded by two smaller plates, and these by three or more, and so on diminishing in size and increasing in number as they graduate into the plates of the dome.

The first azygous plate is as large as a first primary, and rests upon the basal plates. Three plates follow it, one upon its superior edge, and the others upon the upper sloping sides.

From these the plates gradually diminish in size, but increase in number, covering the convex and expanded azygous side.

Dome high, nearly as large as the calyx, lobed, and terminating in a long proboscis either rising from the central part of dome or recumbent.

Surface of the plates more or less covered with radiating ridges and nodes.

Type *Siphonocrinus nobilis* Hall, described in the 20th Rep. N. Y. Mus. Nat. Hist., p. 372 under the name of *Glyptocrinus nobilis*, and illustrated on plate 10, figs. 9 and 10.

Another species *Siphonocrinus armosus* McChesney, was described, in 1861, in *New Palæozoic Fossils*, p. 95, under the name of *Eucalyptocrinus armosus*, and redescribed and illustrated by Hall under the name of *Glyptocrinus armosus*, in 20th Rep. N. Y. Mus. Nat. Hist., p. 373, pl. 10, fig. 11.

THE NIAGARA SHALES OF WESTERN NEW YORK; A STUDY OF THE ORIGIN OF THEIR SUB-DIVISIONS AND THEIR FAUNÆ.

BY EUGENE N. S. RINGUEBERG, M. D.

A few introductory remarks on the stratum immediately underlying these shales will here be proper. This is the *Niagara Transition group* described in 1881.[1] It represents the period of introduction of many of the species heretofore considered as having their inception in the shales, and reveals the cause of their introduction. It also forms the connecting link between the Clinton limestones beneath, and the formation now in question, and explains in large part the comparatively abrupt faunal changes which took place at the time of its deposition.

The Niagara Transition group. Since writing the above mentioned paper I have noted this formation further east at the town of Middleport and as far west as the Niagara gorge, along

[1] The Evolution of forms from the Clinton to the Niagara groups, by Eugene N. S. Ringueberg, *American Naturalist*, 1882, p. 711.

the railroad cut just above Lewiston; at both of which places it presented its peculiar uneven surface and hard texture.

The following Niagara species may be added to the list there given: *Retepora asperato-striata*, *Platyceras angulatum*, *Spirifera crispa*, *Retzia aprinis*, and a small undetermined rhynchonelloid shell of which a few specimens have been found in the shales. *Orthis lynx* must be removed to the list of species common to the Clinton and Niagara, as it has since been found in the shales of the latter. Here also may be added *Orthis elegantula.* Three determined species are characteristic of the group itself, although judging from the material at hand there are many more.

Though this group was regarded as forming a part of the Clinton, the weight of the palæontological evidence proves it to be more closely allied to the Niagara, and confirms the propriety of classifying it as a distinct member of that group of equal value with the others composing it.

It evidently represents a period of comparatively rapid physical change during which the ancestors of the Niagara forms (which had been developing elsewhere, synchronously with the forms representing the latter part of the Clinton here) were suddenly introduced, and mingling with the Clinton species then extant, produced this transitional group.

Various causes might be assigned as the active agents in the production of this change; but the one which seems most probable is a general subsidence of the whole region with concommitant inflowing currents bringing with them an abundance of life from adjacent seas in which a Niagara or Niagara-like fauna was flourishing.

This complete change of both physical and organic surroundings is a sufficient explanation of the complete extinction of the Clinton forms except such as were by nature readily capable of adapting themselves to the new enforced phase of existence.

This same cause would also have its influence on the newly introduced forms, and of these again only such as easily became acclimated and adapted, would survive; especially if the change continued, as is probable, after the initiatory subsidence. For immediately following this period we find a complete and abrupt change in the nature of the sedimentary deposit. Now let us

observe how far this theory is supported by the facts of the case.

The thickness of the shale in western New York and its thinning out in both directions, show that a depression then existed at this point.[1] That this depression was of comparatively rapid formation is shown by the following facts: The shale is deposited directly upon the unevenly *drifted* surface of the Transition limestone, as before noted.[2]

> The upper surface is extremely irregular and undulating; having the appearance of being drifted together. This is also corroborated by the position of many of the fossils which seem to have been swept together by eddies, charged with sedimentary matter, by which they were entombed as we now find them.

This would also account for the perfection of the contained fossils. The spots where no trace of the Transition is to be found, were probably in the direct line of currents that had sufficient force to clear the surface of any deposit which might have been made, and to hold in suspension whatever sedimentary matter they contained. Such currents would also pick up and carry along sueh animal life of this closing scene of the Clinton, free or readily detachable, that lay in their paths; and after their force was spent deposit the same indiscriminately with the mass of foreign matter they had brought with them. There are no regular lines of stratification, as a rule, to be observed in this stratum. Whole groups of species disappeared almost as suddenly as they appeared; such as the *Cyrtoceratidæ*, which are to be found abundantly in some localities in this formation, while immediately before and afterwards they are almost unknown. So it is with quite a number of species which are otherwise strangers in this vicinity.

It is evident, however, that the changed condition of things was more in conformity with the physical surroundings to which the newcomers had been accustomed than that existent during the latter part of the Clinton, for we find a greater preponderance of survivals among the transplanted forms than among the original inhabitants of the region.

With such a birth we can well expect an interesting period

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[1] Prof. J. Hall. *28th Regents Rept. on the N. Y. State Museum*, p. 102.

[2] *Amer. Nat.* ib.

following, provided the conditions favorable to the continuation and multiplication of organic life be maintained; and this expectation is well sustained by the palæontological wealth of the succeeding period.

The Niagara shales. These shales were ushered in with a great profusion of life of many species. At the very threshold of the series we find represented with few exceptions the majority of the species to be found throughout their entire extent. From the beginning to the end there was gradual decadence in the abundance of life, and the number of species, till at last a few fucoids only remained.

These notes on the shales refer strictly to their appearance within the confines of Niagara county. Here, at Lockport, they have a thickness of some seventy feet and can, upon palæontological evidence, be divided into three parts which will be called *thirds*, although that designation will imply merely divisions defined by the comparative abundance and range of the fossils. The first or lower third comprises only some seventeen feet on the Erie canal—the only place where its measurement has as yet been effected. The rest of the series is divided into two parts of some thirty feet each, without any distinct line of demarcation yet noted.

The most conspicuous peculiarity of these three divisions is a regular upward decrease of the fossils. The lower third is highly fossiliferous with comparatively few thin bands of unproductive shale, chiefly in its upper part. In the middle third a diminution may be noted, the fossils being for the most part confined to bands of shale and some thin impure semi-calcareous layers; or to isolated areas or patches. These bands are separated by various thicknesses of shale mostly, but not wholly, non-productive, the fossils growing scarce towards its upper portion. The upper third has a considerable quantity of fossils distributed through it, but they are few when it is compared with the rest of the shale, and are for the most part confined to their well separated layers. Taking these three divisions in order we will describe first in detail *the lower third.*

This extends from the Niagara Transition bed or where that is absent, from the Clinton, to a layer which is well defined palæontologically, and which we will designate as the *Homo-*

crinus band from one of its most characteristic fossils *Homocrinus parvus*. At its inception life was present in great profusion and the lowest portion of the shale is largely made up of a mass nic remains, mostly fragmentary or distorted, principally polyzoa, and disconnected brachiopod valves. But though many species and great numbers are represented good specimens except of the more solid forms are rare. Just here a few single valves of *Orthis lynx* were found, representing the last survivors of this long-lived species, which flourished during the Trenton, began to wane in the Clinton and finally yielded to the struggle for existence here. These first few feet of the shales also bear about the only examples of *Orthis flabella* yet found in them. Here and there also were colonies of *Stephanocrinus angulatus* and *S. gemmiformis*; the latter of which seems to have extended but little higher while its congener gradually decreased in numbers, a few occurring part way up the *middle third* while few if any are found above it. The largest examples of *Illænus* are also to be found here equalling and exceeding the largest from the Clinton, though unfortunately almost invariably in the shape of disjointed cephalic shields and pygidia, some of them measuring eight centimeters across—while a little higher up those exceeding three centimeters are scarce. *Illænus ioxus* is the form generally found, but, judging from fragmentary evidence there are one or two others having varietal if not specific values. There certainly was a marked decadence of this species, especially as regards size, after the close of the Transition, in which, and the underlying Clinton, the larger form evidently predominated. *Calymene* also underwent a similar retrogression in size after leaving the Niagara Transition. *Dalmanites limulurus*, *Homalonotus delphinocephalus* and *Lichas boltoni* although present do not begin to increase in numbers till towards the middle of this lower third, *Homalonotus* not arriving at its maximum until the next division is reached; while *Lichas* evidently culminated in the upper half of this one; although it is present all through the *middle third*, with a rare fragment beyond. *Lichenalia concentrica* is at its maximum from the very start and gradually with varying fluctuations fades away till lost in the *upper third*. So it is with *Streptelasma calyculus* which however decreases more rapidly in numbers and size;

nearly all the large specimens being in the first couple of feet. *Strophomena rhomboidalis* drops from six centimeters or more as the maximum size in the lowest band to three in the *upper third.* The *Merestinæ* are to be found in the greatest abundance in the lower portion. Colonies of the larger species at times multiplied largely to the exclusion of other life. After this first portion the *Graptolitidæ* began to increase, though in varying quantity and occasionally wanting, into the *upper third. Inocaulis* however seems to go but little beyond this section.

Some of the omnipresent species such as *Spirifera niagarensis; Atrypa reticularis; Atrypa nodostriata; Merstina nitida* and its var. *oblata; Strophomena rhomboidalis; Rhynchotreta cuneata* var *americana; Platyceras angulatum; Platystoma niagarense Streptorhynchus subplanum*, and some others, are to be found in varying quantities throughout the three sections till near its close, where they of course are few in number. Some extend further upward than others before dying out and will again be referred to in speaking of the other portions.

Some of the rarer fossils seem to be almost entirely confined to this third, only an occasional specimen being found in the other horizons.

Of these we may mention, *Atrypa rugosa*, *Rhynchonella obtusiplicata*, *Anastrophia interplicata*, *Callopora nummiformis*, *Calceocrinus radiculus*, the *Eucalyptocrini*, *Icthyocrinus lævis*, *Ceratiocaris dewyi*, *Macrostylocrinus fusibrachiatus*, and *M. ornatus*, *Inocaulis anastomatica*, *Conularia bifurca*, and the *Lecanocrini* except *L. macropetalus.*

The Homocrinus band. This band represents the close of the *lower third.*

Perhaps the most abundant species to be found is *Spirifera niagarensis.* Various other brachiopods and some of the characteristic Niagara forms are to be found here. But it is not till we come to a consideration of the echinodermata that we find distinctive features. Of this class there are more striking examples collected together in the same stratum, to which many of them appear to be confined, than we have found in any other single portion.

Homocrinus parvus; this graceful pigmy crinoid with its long slender thread-like columns and attenuated arms

has been found both singly and in groups at the only two accessible exposures known; and as it has been found nowhere else and seems to be the most constant form the band has been named after it. The fine almost black tracery of its columns is generally seen associated with few other fossils. *Hemicystitites parasiticus* is another species which I have never found elsewhere. All specimens collected by me show them to be parasitic on *Spirifera niagarensis*, but Prof. Hall mentions having secured it also on *S. radiatus.*

The specimens usually occur on individuals, in the colonies of the former species, and sometimes two may be seen side by side on the same valve. In this connection it may be mentioned that a peculiarity of *Spirifera niagarensis* is that it is gregarious, living in small sized colonies so that the specimens at times almost completely cover slabs of shales, with comparatively few individuals in the intervening spaces.

This band has also yielded the only star fishes so far found, except *Palæaster niagarensis*, the exact horizon of which is unknown, as Prof. Hall refers the single type specimen indefinitely to the shale at Lockport. These consist of eight individuals of *Protaster stellifer* and a type each of *Eugaster concinnus* and *Squamaster echinatus.*

Next to these the *Lecanocrini* are the most characteristic group. The species of this genus are confined mostly to the lower third except *L. macropetalus* which is found in the middle third. The rest range sparingly through the lower third and terminate here with many species and more individuals than in all the rest of the shale. A species which resembles *L. calyculus* is the most abundant; the others are *L. excavatus*, *L. macropetalus*, and *L. nitidus*. These except *L. macropetalus* seem to be peculiar to this band. *L. solidus* and *L. puteolus* are from the lowest band of the lower third. The fine state of preservation of many of the specimens occurring in this band and the layers immediately above and below it, is noteworthy. This is especially true of species as a rule found only in a disconnected condition. Of these the well known *Caryocrinus ornatus* is the most prominent example. The portion of the shale within a few feet in either direction from the Homocrinus band has yielded the most perfect specimens of this species which have

thus far been found. Some magnificent ones with a goodly proportion of the column and arms intact have been secured. This species makes its first appearance in the Clinton, where it is very rare, passes through the Niagara Transition, appears in slightly increased numbers, rapidly augments its ranks and reaches its maximum in the upper portion of the lower third; extends in moderate numbers up into the middle third, before leaving which it rapidly subsides, being almost unknown in the higher portions of the upper third. After a temporary emigration to more favorable haunts it returned and is again found in the limestones immediately above; after which time it probably became extinct. Coincident with the preceding is the rise and fall of Dalmanites.

Here also are found the best examples of *Myelodactytus brachiatus* which, though rare, occurs uniformily through the *lower third.*

The middle third. This and the divisions following are defined by the negative evidence afforded by the absence of many species. A few exceptions may be made, the most prominent being the development of *Homalonatus* which reaches its maximum size after leaving the Homocrinus band, and extends upward though in diminished numbers into the highest fossiliferous beds of the *upper third.* A more careful stratigraphic classification may yield some species of polyzoa which will be found peculiar to it; thus the rare *Clathropora frondosa* has as yet only been found in its upper portion, and possibly extends into the third above. *Striatopora flexuosa* is found here, and but rarely elsewhere. The few specimens of *Cornulites* and *Stomatopora* are mostly from within its borders as is also the case with *Tentaculites niagarensis* and its almost universal associate *Beyrichia spinosa* and the rarer *B. symmetrica* which are mostly from its upper part. This latter trio extends into the *upper third.* The types *Tuberculopora inflata*, *Crania pannosa*, *C. dentata* and *C. gracilis* occur here. The only other *Crania* known from the shales is a species which I have considered as identical with *C. siluriana*, which has only been found in the *lower third. Callocystites tripectinatus* also occurs here.

The most notable absentees are among the crinoids and cystids referred to as peculiar to the *lower third.* After these come the brachiopods which have before been listed.

The upper third. Two of the most constant fossils which attain their best development in t' 's division are *Rhynchonella neglecta* and *Streptorhynchus subplanum*. *Pterinea emacerata* is the principal lamellibranch. Among the trilobites *Dalmanites* and *Homalonotus* are the prevailing forms, others being seldom found. Corals are scarce, being principally an occasional *Favosites*. Cephalopods are almost entirely wanting, *Orthoceras annulatum* being the only one noticed. *Platystoma niagarense* is the only noteworthy gasteropod. Crinoidea are excessively rare, a few *Caryocrini*, a *Callocystites jewetti* and a type each of *Mariacrinus warreni* and *Dendrocrinus celsus* being all that have been secured to date.

It will be observed that most of the recorded species are in the *lower third*; this is not alone due to the profusion of fossils there, but also to the more limited facilities for observation which have occurred in the rest of the shale, and the immense amount of material which must be worked over in order to get a few data.

NOTES ON THE PITTSBURG COAL BED AND ITS DISTURBANCES.

BY HENRY A. WASMUTH, M. E.

The Westmoreland Coal Co. has opened the Pittsburg coal bed by a shaft at station "Biddle" on the Pennsylvania Railroad. The shaft has struck the coal bed at about 190 feet deep on the northern flank or flexure of a basin, the synclinal axis of which has not been developed thus far. The area of the northern flank, controlled by the company referred to, has been opened on the English and German systems of mining by dividing both extensions of the coal bed on the strike as well as on the incline into suitable pannels or divisions. Each pannel on the strike has three main entries, one for the empty mine wagons, one for the loaded wagons and the third one for the returning air (A B C, fig. 1). From these main entries are ur ned off the butt entries D D D D (double entry system), thus

dividing into pannels e extension on the rise, an' om the latter the rooms E E E or coal mining are turned off.

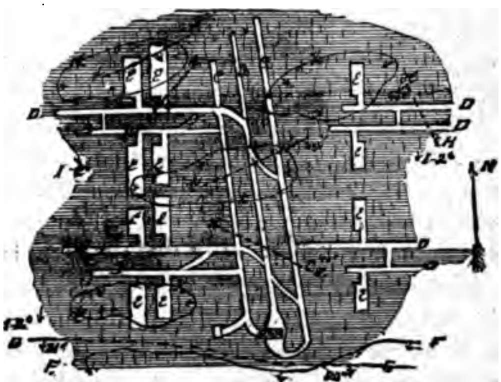


Fig. 1.

The particular feature of the coal bed in this district is its distinct and regular cleavage, thus promoting mining of lump coal; the faces of the main slips are the faces of the rooms.

The distance from the shaft to the most inside faces of the main entries is about one mile. An output of 1000 tons of screened coal per day of ten working hours can be furnished without any force on account of the most perfect working order of all details concerned.

In extending the mine workings it has been developed, that the northern flexure of the synclinal referred to, rises at an average of 1 to 3 per cent. or hardly 1½ degrees; but the flank of the basin consists really of a combination of numerous, very gentle dipping rolls or synclinals and anticlinals, K K K, fig. 1, in both directions, strike and dip. The anticlinals are called "hills" and the synclinals "swamps" and both are accompanied by numerous disconnections and dislocations of the coal bed and its country rock (roof and floor), but in accordance with the very gentle dip of the hills and swamps the dislocation mostly is trifling, exceptionally from 1 to 1½ feet vertical. The disconnection of the coal bed and roof work is complete and distinct, the original projections of fracturing being rubbed smooth by continued sinking of one part of the measures or by disproportionately sliding of both parts of the measures. The disconnections and dislocations indicated H H H, fig. 1, generally are termed "clay veins," "spars," "slack veins." The courses of the clay veins differ, thus crossing each other, and the same clay vein might be cut in several entries and rooms. These

clay and slack veins, according to the terms of geologist Rogers and all authorities, are transverse and longitudinal faults, and although small in extent they prove beyond doubt that the coal beds and rock at the time of the disturbance from their original horizontal position, have been as hard as to-day, which will be explained in the following.

The synclinals or "swamps" indicated in fig. 1, dip very gently; sometimes their deepest point is hardly two feet below the corresponding point of the anticlinal. The shortest line between two corresponding points of two anticlinals and through the corresponding point of the synclinal is longer, as the shortest connection of the two points of the anticlinals; consequently if the coal and rock had been in a soft or plastic state at the time of the disturbance from their original position, in order to cover the greater length they must have been thinned out by the over-lying measures, either with or without more or less fracturing; *i. e.* by upheaval the measures of the anticlinals must have been thinned out. The facts demonstrate, that the thickness and lamination of the coal and rock remain uniform all over such synclinals (*i. e.* anticlinals) and in order to cover the greater length the coal bed and country rock are disconnected as illustrated in fig. 2. By a great number of disconnections of the measures in the mine referred to, always the fracture of the roof rock is smooth and sometimes polished and with distinct striation, although irregular in its course; and from these facts must be concluded, that the coal and rock have been hard at the time of the disturbance from their original horizontal position; that fracturing took place when the sinking of the measures commenced and that the disconnected hard measures by continued sinking rubbed on each other and the fracture widened out, thus producing the results described before. Had the rock been soft or plastic at the time of the disturbance no such smooth polished and striated planes could have been produced, because only hard substances smooth and polish each other by friction. The width of the fracture of the coal bed, fig. 2, differs from a few inches to two and three feet, and while the sinking has been so trifling the projections of the fracture remained in their original shape, the

fracture being filled with disintegrated fire clay (roof of the coal.) Such occurrences are termed "spars."

Fig. 3. representes a disconnection and dislocation of the coal and measures, the fracture dipping with the course of the dip of the measures. The fracture F mostly is several inches wide (and more) and it is filled with disintegrated coal and country rock (clayish substance). Consequently it represents a body, more precisely a clay-lode, which mostly has a greater incline than the mineral deposit, disconnected by it. If the terms of a mineral deposit—roof, floor, top, bottom, hanging wall, footwall—are applied to it, then the part of the coal bed on the hanging wall of the fracture is in a lower position, than the part on the footwall, which is the characteristic of "transverse faults."

Fig. 4. represents a dislocation of the strata, the fracture dipping contrary to the dip of the measures, and the part of the coal bed on the hanging wall of the fracture or fault is in a lower position than the part on thefoot wall. The effects of such faults are similar to those of faults represented in fig. 3, but they are termed "transverse faults with contrary dip."

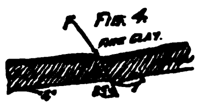
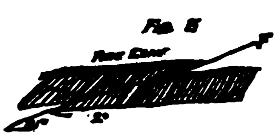


Fig. 5. represents a disconnection of the coal bed and measures by two faults, one F F with regular and one F with contrary dip but without dislocation; perhaps their effects have been compensated. The steeper dipping fault has died out on the regular dipping fault. Such occurrences appear numerous and it is obvious that their courses differ and consequently cross each other. Both fractures are transverse faults.

Fig. 6 represents a so-termed "slack-vein" (G G, fig. 1) which has been developed for a distance of more than 1000 yards long in the mine referred to and it is the only one met with in that district thus far. F F, in fig. 1, approximately represents the water level, *i.e.*, strike line of the coal bed devel-



oped by the mine workings. It will be seen, that the strike line of the slack vein is somewhat parallel with the strike line of the measures. The fracture F or slack vein is about two inches wide and it is filled with disintegrated coal only, because the part of the coal bed on the foot wall of the fracture has slid down, or even both parts disproportionately, thus the projections of the fractured coal only have rubbed on each other and as the vertical dislocation is only about six inches, no disintegrated top rock could be dragged along. The measures on the foot wall of the fault are in a lower position than the measures on the hanging wall of the fault, which is the characteristic of "longitudinal faults" or "overlaps" and the "slack vein" referred to according to the terms of geologist Rogers is a "longitudinal fault" or overlap, or according to Heim, Koehler and other authorities, a "folding fault."

The course of transverse faults mostly approaches the course of the incline of mineral deposits (lode-measures); the part of the deposit on the hanging wall of the fault has slid down, and is in a lower position than the part on the foot wall but, where the dislocation is trifling and not distinct, mostly both parts of the coal bed have been slightly bent downwards on the fault.

The courses of longitudinal faults mostly approach the course of the strike line of the measures and the part on the hanging wall of the fault or fracture is in a higher position than the part of the measures on the foot-wall.

The dip of transverse and longitudinal faults generally is greater than the incline of the deposits and measures, but in ore lodes, according to their origin, occur no longitudinal faults.

It is a well-known fact, that clay veins, rather faults, of more or less extent, have been struck in a great number of mines on the Pittsburg coal bed. An investigation of several districts will prove also that the Pittsburg coal bed to a degree is devided into areas of more or less extent by erosion and clay veins, the latter crossing each other. Furthermore it is a well known fact that the filling of fractures and faults by clayish substance acts like a dyke against water and gas, demonstrated in coal mining in Europe and in the anthracite region.

The Pittsburg coal measures are underlaid by the Devonian formation, or members of it, the reservoirs of oil and gas. It

must be accepted as a fact, that the disturbances of the Pittsburg coal measures, to a certain degree, must have affected the underlying Devonian formation and even the formation at the bottom of the latter, thus forming areas of more or less extent by clay veins etc.—Naturally, the greatest amount of gas should be found on the higher elevations (anticlinals) and of oil in the deeper portions of main and minor synclinals of the Devonian formation, or members of it; but as this theory is refuted by geologists of reputation, which certainly will prove to be correct, there remains especially the influence of disconnections and dislocations of the oil and gas bearing strata by clay veins, etc., heretofore not mentioned at all, to explain the productivity of the oil and gas wells of Pennsylvania.

GEYSERITE IN NEBRASKA.

BY DR. LEWIS E. HICKS.

In many counties of Nebraska occurs a fine, flour-like, white, or grey deposit, which is used as a polishing powder. It excites much curiosity in localities where it is newly discovered, and specimens of it are constantly being sent to the university for identification. I have just received a specimen from the northern part of the state with the inquiry whether it is emery.

Prof. J. E. Todd published in Science, Apr. 23rd, 1886, an account of its occurrence in Seward county, Nebraska, in strata of Quaternary age. He sent samples to Mr. J. S. Diller of the U. S. Geological Survey, who replied that it was *volcanic dust.*

I have lately received a sample from Lindsberg, Kansas, and Mr. J. A. Udden, who sent it, has since informed me that, having forwarded samples to Washington, he was informed, by a member of the U. S. Geological Survey, "that it was *volcanic dust.*

I wish now to recall the fact, once known to some portion at least of the geological world, that Prof. Samuel Aughey has given an extended description of this mineral in his "Physical Geography and Geology of Nebraska," published in 1880. His description is so full, minute and exact that it deserves to be reproduced entire. It is as follows:

Polishing Powder—Infusorial Earth—Geyser Flocula. One of the most remarkable of all the deposits of this Pliocene lake of the plains, is a

peculiar flour-like material that appears in beds of greater or less thickness and extent on the Republican, Loup and Niobrara rivers, and in other sections of the state. When I first examined it under the microscope a few diatoms were collected, from which circumstance it was regarded as probably of the character of tripoli. Since then, in many specimens that have come under my observation,a diatom has rarely been found. The chemical analysis of this earth is, moreover, very different from tripoli. It is proved to be a silicate of the alkaline earths, and most generally of soda, potash, magnesia, and lime. Sometimes only one, and sometimes several of these alkalies are present. It ranges in color from light gray to snow white, green and yellowish. All these colors are sometimes found in the same bed, and the chemical composition varies even more than the color. To the touch it feels very much like flour. The best specimens have no grit, and when used as polishing powder no scratches can be detected, even with the microscope. It is most abundant along the Republican river, where it is found in almost every county. It is exposed on the east half of the northeast quarter of section eight, and on the west half of the northwest quarter of section nine, town three north, range twenty-one west of the sixth principal meridian, in Furnas county, south of the Republican river and about eight miles southeast of Arapahoe. One of the exposures here is nearly a quarter of a mile long, and is a characteristic section. The measurements are from the top down.

Loess	6 feet
Drift (?)	8 "
Compact silicate of lime and limestone	8 "
Flour-like earth	12 "

This bed is made up of layers one fourth of an inch in thickness, of snowy whiteness, and other layers, from nine inches to a foot thick, of a grayish white color. Nine feet from the top there is a layer two inchcs thick of a greenish color, which contains potash and iron.

As already intimated it polishes as successfully and as finely as the best tripoli.

Origin of this Flour-like Earth.--Near or in many of these beds are found many extinct geyser tubes, and sometimes old geyser basins. Of these I observed at least thirty between Arapahoe and the west line of the state. I have also found them in the Loup region and on the Niobrara.

As some of these geyser tubes had their exit in the Fort Pierre group, on the upper Republican, it is probable that they commenced their work in the Cretaceous period, and were in operation all through the long centuries of the Eocene, Miocene and Pliocene epochs, and far into the Quaternary. A similar bed exists on Oak creek which was deposited in interglacial times. Nebraska and northern Kansas was in fact a great geyser region all through the Tertiary period. Few memorials of these extinct geysers are visible at the present time, owing to their being covered up by the superincumbent Quarternary deposits, but enough remain to show that a prodigous number must have existed. It is probable that

this flour-like silico-alkaline earth owes its origin to these old geysers. It is well known that hot alkaline waters dissolve silica. When, therefore, the geyser streams holding silica and alkalies in solution were poured into this old lake the mineral in question was precipitated. Indeed many of the flakes of this earth, under the microscope, clearly resemble the dried flocculent flakes of aluminic silicate which the chemist obtains by pouring soluble sodic silicate into a solution of sodic aluminate.

Another fact which tends to establish the probability of this theory is that this silico-alkaline earth, on analysis, bears a striking resemblance to *geyserite*, which is obtained from the deposits of existing geysers. The following analyses are illustrations of this statement. No. 1 is an analysis of this earth from the deposit near Arapahoe; No. 2 from the Loup region; No. 3 from Iceland; and No. 4 from the Yellowstone. Nos. 1 and 2 were made by myself; No. 3 was made by Forchhammar; and No. 4 by Dr. F. M. Endlich.

	No. 1.	*No. 2.*	*No. 3.*	*No. 4.*
Loss on ignition	....	....	....	8.00
Silica	67.01	80.17	84.48	76.80
Water	8.08	7.48	7.88	5.00
Alumina	7.11	4.71	8.07	9.46
Iron	2.81	8.01	1.91	trace
Lime	2.01	0.92	0.70	1.80
Soda and potassa	7.87	2.27	0.92	trace
Magnesia	4.05	0.80	1.06	trace
	98.89	99.81	99.98	101.06

From these analyses it is evident that the principal difference between this Pliocene earth and geyserite is that the former contains a much larger per cent. of alkalies; though the specimen from the Loup is much like the geyserite from Iceland. By reference to Dr. Endlich's report on the composition of the geyserites of the Yellowstone[1] it will be seen that they differ very much in the proportions of their constituent elements. In the great number of analyses reported by him from as many different geysers, no two are alike. Often geysers only a few feet apart produce very different qualities of geyserite. The same is true of this peculiar earth under discussion. It not only differs a great deal in different localities, but even in different layers of the same stratum. It differs most in the quantity of the alkalies which it contains. Some specimens contain twenty per cent or more, while others contain only a trace, the latter approximating closely in chemical, though not in physical constitution, to the true geyserite. I submit whether these facts do not indicate a similar origin. It is possible that the peculiar modification of geyserite into a flour-like alkaline silicate may have resulted from geysers that were active in the waters of this old Pliocene lake.

The deposits of a similar character in the Quaternary contain, where

[1] Hayden's Report for 1872, p. 157.

I have chemically examined them, a larger per cent. of iron, and are coarser in texture.

It is but justice to Prof. Aughey that his account of this deposit should be accredited for all it is worth; and it may be the means of correcting an error. I do not assert that the opinion which seems now to be widely entertained is erroneous. I wish to provoke further investigation.

The relation of the silico-alkaline earth to one of the extinct geyser tubes was recently observed in the Loup region by Mr. F. W. Russell. He also reports a *warm spring* in that region.

The condition of fine powder which the mineral in question usually presents is not a serious objection to its being regarded as geyserite. The explanation may be such as Prof. Aughey suggests; besides ordinary geyserite often falls to powder on exposure. The specimens which I have seen from Nebraska were all in fine powder, but Prof. H. H. Nicholson of this University assures me that it does occur here in the form of solid incrustations as in existing geyser regions. The specimen from Kansas has greater solidity than any I have seen from Nebraska, but it is quite friable.

A CONTRIBUTION TO THE ARCHÆAN GEOLOGY OF MISSOURI.

WITH PLATE I.

BY ERASMUS HAWORTH.

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(*c*) Structure of the porphyries. (*d*) Classification of the porphyries.

C. Diabase and Diabase Porphyrytes including all the dyke rocks.
(*a*) Mineralogical composition. (*b*) Special description of minerals.
(*c*) Structure of the diabases. (*d*) Classification of the diabases.

D. General Conclusions.

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Swallow, G. C.: Metamorphic and igneous rocks of Missouri. Mo. Geol. Rep., 1855. Part I.

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A few other notices and short articles have been published in different journals, references to which I could not obtain.

I.—GENERAL CONSIDERATIONS.

A. Geography.

The area covered by the work of which the following is a summary lies in the vicinity of Pilot Knob, and Iron Mountain, Missouri. This famous mining district is known by name to almost everyone. It lies on the main line of the St. Louis, Iron Mountain, and Southern railroad, southwest of St. Louis about eighty-five miles. The principal places mentioned is this paper are located as follows: Iron Mountain, eighty-two miles below St. Louis; Pilot Knob, eighty-seven; Ironton, one mile below Pilot Knob. It is the county seat of Iron county, and the largest town in the district described; Piedmont, about thirty miles below Ironton; Syenite, a granite quarry, fifteen miles east-northeast of Ironton; Mine La Motte station, sixteen miles east of Ironton; the mines by this name are two and a half miles farther east; Graniteville, three miles northwest of Pilot Knob; and the Silver Mines, ten miles southeast of Ironton.

The only two streams which will be referred to very often are the St. Francois river and Stout's creek. The former rises near Graniteville, flows to the north a short distance, then forms a big horse-shoe curve and flows south, passing Syenite and the Silver Mines. Stout's creek passes south of Ironton, then flows almost due east to the St. Francois, thus shutting in a large area in the horse-shoe bend of the St. Francois.

The Archæan area covers irregularly outlined portions of no less than ten different counties. To the west it extends as far as Texas county; to the north and northeast as far as Washington, St. Francois, and Ste. Genevieve counties. To the east it passes through Madison county; and to the south nearly through Wayne county. But only a small portion of this territory is covered by the Archæan rocks.

Throughout the whole Archæan area the surface is exceedingly rough. Narrow valleys along the streams with high and irregular hills beyond, rising from three to six hundred feet, is perhaps as good a description as can be given. Sometimes there is a long divide between two streams which is much more nearly level than the hilly portion just mentioned.

B. Statement of Work.

It is attempted in the present paper to give the results of a reconnaissance of the Archæan area in Missouri, and a somewhat detailed petrographical description of a portion of the massive rocks occurring therein. There is such an inter-dependence between the field relations of crystalline rocks and their microscopical and chemical properties that, in order to gain a complete understanding of the geology of any territory, one must alternate field observations with microscopical and chemical studies. The field work cannot be carried very far in advance of the laboratory investigations, neither can one draw correct conclusions from the latter if they are not accompanied by extensive and accurate field observations. No work of this character has before been attempted in the Missouri Archæan. From the very necessities of the case, therefore, this paper must be of a preliminary nature. It is hoped that in the near future circumstances will permit a continuation of the work thus begun in this interesting field. The information used as a basis for the present paper was obtained partly from others, but principally from observations made in the field during the summer of 1886, and the subsequent examination of materials collected. Mr. Richard Payne, of Madison county, has sent me over a hundred hand specimens from localities not visited by myself. Prof. G. C. Broadhead, formerly state geologist, has also kindly loaned me portions of his private collection of rocks from this locality. Individually I traveled over considerable portions of Iron, Madison, and Wayne counties, going as far north as Bismarck, as far east as Mine La Motte, as far south as Piedmont, and as far west as the northeast corner of Reynolds county. Special efforts were made to collect typical specimens of all the massive rocks, whatever they might be.

In the laboratory investigations I have been assisted by Mr. Charles E. Coats, of Baltimore, Md., who kindly made a silica determination of the quartz-diabase described later by Prof. C. R. Van Hise, of Madison, Wis., who gave me valuable suggestons regarding the microscopic character of a large number of thin sections sent him; but far more extensively by Prof. G. H. Williams, of the Johns Hopkins University, in whose laboratory

the greater portion of these investigations have been conducted. It is with pleasure that I make use of the present opportunity to express my gratitude to all of the above named gentlemen for their kindnesses, and especially to my honored teacher, Prof. Williams, who was ever ready to give assistance and advice, and to whose untiring interest such value as this paper may possess is largely due.

C. General Geology.

(*a*) The general geology of the Missouri Archæan is very simple. There are no contorted or twisted strata, and no high angles of dip showing violent orographic movements. Every thing indicates that the movements which have occurred were of the most gentle kind. The rocks themselves do not present a very great variety. There is a total absence of any thing approaching gneiss or schist.[1] Different kinds of porphyry—which is the predominating rock—granite with simple and almost constant mineralogical composition, and dykes of diabase and diabase porphyryte constitute nearly all that can be referred to the Archæan.

(*b*) *Relation of stratified to massive rocks.*

Limestones and sandstones occur along the valleys and sometimes on comparatively high ground throughout almost all of the Archæan area. It is probable that from those places where granite is exposed in the valleys, as along Stout's creek and the St. Francois, the sedimentary rocks have been carried away by erosion. Pumpelly[2] and Broadhead[3]—and in fact every one else who has written on the subject—referred the granites and porphyries to the Archæan, and the limestone and sandstone to the Silurian. In the geological map issued with the 5th An. Rep. of the Director of the U. S. G. S, the sedimentary rocks

[1] Pumpelly mentions a rock with "schistoid structure,"--Mo. Geol. Rep., 1872, p. 26—which he thinks is a limestone changed to porphyry. He says: "Here is a member of the porphyry series which was unquestionably a limestone, but in which the original physical and chemical characters have almost wholly disappeared." Not having seen such a rock I can say nothing about it.

[2] Mo. Geol. Rep., 1872, p. 8.

[3] Mo. Geol. Rep., 1873-74, p. 347.

are called Cambrian. All of my observations accord with these views with reference to the relative ages of the different rocks. There can be no doubt that the granites and porphyries are older than the sedimentary rocks, as the following considerations show:

1°. Numerous instances were seen in which the stratified rocks overlie the massive ones and are non-conformable with their surface. Broadhead also describes and figures such contacts.

2°. The stratified rocks in the whole country are nearly horizontal, rarely showing a dip of more than ten degrees. It is very probable that this would not be true had such large quantities of massive rock been forced up through them.

3°. Nowhere has a contact zone of metamorphosed limestone or sandstone been observed. Had such large quantities of massive rocks been forced up through the stratified ones it is very probable contact metamorphism would be common.

During Cambrian time this portion of Missouri existed as an archipelago of many small islands, some of which had deep, narrow valleys between, while others were mere peaks separated by five, ten, fifteen or more miles. Along these valleys the Cambrian rocks were deposited.

(*c*). *Relation of massive rocks to each other.*

Long before Cambrian time, however, these islands had a history. They had been lifted above the ocean waters and subjected to different kinds of degradation. Along their shores and upon their hillsides deposits of their own material had been made which were subsequently firmly cemented together forming a breccia. The material of the cement is very like that of the fragments, so that it is often difficult or even impossible to distinguish between the two. At present this class of rocks must be almost entirely neglected, because the ascertained facts are too meagre to warrant a discussion of them. It is quite probable they have been given too prominent a place by those who have written about them.

So far as observed the granites are on comparatively low ground. Graniteville is in a valley, with high hills almost all around. The granite quarries at Syenite are on the banks of

the St. Francois. The quarries along Stout's creek are at the water's edge. These are the localities in which the best crystallized granites occur. As we go back from the streams towards the hills the surface is usually covered with soil, so that the rocks can not be seen. The hills are almost invariably composed of porphyry. There is a considerable area of granite exposed to the west of Syenite, on both sides of the county line between Madison and St. Francois counties. This is on the highest ground of any granite exposures observed. In appearance these rocks very decidedly resemble the porphyries, much more so, at least, than do the granites of the valleys. In other cases the porphyries seem to be very coarsely crystalline for such rocks. At the base of the hill just west of Hogan a rock occurs which is difficult to classify. It seems to be half-way between a granite and porphyry. Farther south the porphyrytes are so coarsely crystalline they can very well be worked for paving stone. Numerous places along the road south as far as Piedmont furnish excellent quarries of such rocks. By combining the rocks from these different localities, we have a continuous series from the best crystalline granite of Granitevile, to the most fine grained felsophyre.

(*d*). *Surface decomposition.*

Surface decomposition has progressed to a considerable extent in some localities. About ten miles west of Pilot Knob there are a number of different places in which the porphyry is changed to an impure kaolin. At Iron Mountain the surface decomposition is very great. When mining was first begun the whole surface of the hill was covered with clay through which the iron was disseminated. At present quite fresh rocks are exposed in some parts of the mine, while in others they are very rotten.

The rocks on the southwest side of Pilot Knob are very badly decomposed, as has been shown by borings and diggings. In other places similar decomposed areas are met with. Yet one is perfectly correct in saying that the great masses of the rocks are comparatively fresh. With but few exceptions one can get a good, fresh hand specimen by using a hammer on the ledges of any hill-side.

(*e*). *Dykes.*

In numerous places throughout this whole country dykes of various sizes occur, sometimes in the granite, sometimes in the porphyry, and, as stated by Broadhead, sometimes in the sandstone. It is difficult to determine the age of these dykes. In nearly all cases they occur in the massive rocks in places where there are no overlying sedimentary ones. The presence of one of them in the sandstone would indicate that probably they were formed after it was deposited. But in the report just mentioned, on page 372, Norwood speaks of a dyke which is overlaid by the sandstone. It seems probable, therefore, that the great majority of them are of Archæan age, while possibly a few are younger.

These dykes are most abundant in Madison county, but are known in many other places. Their most common trend is northeast and southwest, or approximately parallel to the Ozark hills. The dykes vary in size from a fraction of an inch in diameter to more than forty feet. It seems that they rarely if ever overflowed the surface; or, if so, the material has been carried away by erosion.

II.—PETROGRAPHY.

The massive rocks of Missouri may be divided into three general classes or families. 1°, Granites. 2°, Porphyries and porphyrytes, exclusive of the dyke-rocks. 3°, the dyke-rocks, which are varieties of diabase and diabase-porphyryte. They will be described in the order given.

A. Granites.

(*a*). *Mineralogical composition.*

The mineralogical composition of the granites is not at all complex or varied. The great mass of the rock is composed of quartz and orthoclase. Other minerals are always present, but in comparatively small quantities. They are microcline, plagioclase, biotite, hornblende, apatite, zircon, fluorite, topaz, and iron-oxide—probably magnetite. To these must be added the secondary minerals; chlorite, epidote, muscovite, leucoxene, and calcite. Sometimes the biotite is sufficiently abundant to give

the rock a mottled appearance, and in fact it is not often entirely absent. But it never occurs in half the quantity in which it is often seen in biotite granites from other localities. The hornblende, when present, is always associated with the biotite, occurs in much smaller quantity than the latter, and is generally in idiomorphic crystals. These two minerals are quite fresh at times, but more often are considerably altered. The alteration products are those commonly observed; chlorite, epidote, etc.

All the other minerals named occur in small quantities, and the most of them present no special points of interest. The apatite needles are unusually free from the breaks, or fractures so common to them in rocks from other places, and when they are broken their fragments are not moved out of place, a fact in harmony with the field relations which indicate gentle movements of the rock masses.

The zircons are very abundant, and are often clustered around little fragments of biotite or hornblende, sometimes thirty or more being in one group. The dark, pleochroic zones so commonly seen around zircons in granites and other rocks from different places, are very often present in these granites. The size of the zircon crystals is not great, the largest one seen measuring only 0.118 mm.

Epidote occurs only as a secondary product from the biotite, hornblende, or feldspar. The muscovite is also secondary, and occurs in small quantities. The same is true of leucoxene and calcite.

Only those constituent minerals which are especially interesting will be mentioned in detail.

(b) Special description of minerals.

Quartz. The quartz has the limpid appearance so common in granitic quartz. The granules vary in size from more than a centimeter in diameter to those of microscopic size. There is often a decided approach to an idiomorphic structure, even in the most highly crystalline granites. This is well shown in specimen number 303, obtained at Knob Lick as it was being loaded on to the cars for shipment. It was said to have come from a quarry about two miles north of Syenite. In a thin section from this specimen one individual quartz crystal shows

the ∞R and R faces well developed, as is shown in fig. 1. The quartz grain is almost entirely surrounded by feldspar crystals. Such idiomorphic quartz is very important in considering the structure of the granites.

Another very interesting feature of the quartz is the unusually great abundance of fluid inclusions. They vary from 0.025 mm. in diameter to so small a size that they can scarcely be seen when magnified 300 diameters. Gas bubbles are often present, but no one was observed which was in motion. Little cubic crystals—sodium chloride?—were quite common in number 232.

Fig. 1.

x 40 diameters.

This shows an idiomorphic quartz in granite, with R. and ∞R well developed. It is surrounded by decomposed orthoclase, plagioclase and quartz. From specimen number 803.

Very frequently these fluid inclusions are arranged in lines approximately parallel, and also are sometimes in planes cut by the section at different angles. These recall the "solution planes" of Judd.

It is very rare indeed to find anything at all resembling the hair-like inclusions so common in granitic quartz which Hawes[1] thought to be rutile needles. In a thin section made from a sandstone just north of Mine La Motte station, however, many such inclusions were seen. Now if the sandstone was formed from the disintegrated granites and porphyries near by, it is strange that the first section made from it would show more of these inclusions than can be seen in nearly two hundred sections of the granite and porphyry.

Orthoclase. The orthoclase in nearly all thin sections examined has a strong tendency to assume an idiomorphic structure. The faces oP, ∞P and $P\infty$ are frequently quite well developed. It is not uncommon to find beautiful micropegmatite occuring in the same specimens with these idiomorphic crystals.

The orthoclase is often quite badly decomposed, but the granites from the quarries are quite as fresh as the average

[1] Mineralogy and Lithology of New Hampshire.

New England granites which are found in the market. Muscovite is one of the most common products of alteration. In the granites from Graniteville many very minute, isotropic, strongly refracting grains of secondary origin occur which probably are garnets, but on account of their very minute size this could not be proved.

A very interesting occurrence was observed in several of the granites which seems to be an enlargement of orthoclase individuals by a process of secondary growth. In all such cases the original crystals are decidedly idiomorphic. The material of the secondary growth is attached to these original crystals and is oriented with them. Sometimes the new material extends entirely around the crystals. as shown in fig. 2, b; in other cases only a part of the way, as represented in fig. 2, a. In still other cases the border of new feldspar material is continuous a portion of the way, the remaining part being occupied by a micropegmatite in which the feldspar is attached to the original crystal and is oriented with it. This is shown in fig. 3. A fourth form, as represented in fig. 2, c, consists of an entire border of micropegmatite in which the feldspar is in rod-shaped portions projecting outward from the original crystal to which they are attached and with which they are oriented. Thus there exists a complete series, from the feldspar crystals with the entire rim of the secondary growth to those with the micropegmatite border all around. Sometimes cleavage lines extend from the original crystal out through the attached part. In other cases there are lines in the secondary border which do not extend into the original crystal, and which are not parallel to its cleavage lines. In such cases it would seem that the growth began as in the micropegmatite border and continued until the individual rays united forming a solid zone. Each one of these rays, of course, would be oriented

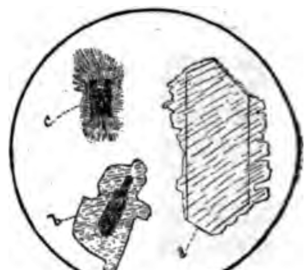

Fig. 2.

x 40 diameters.

a and *b* are from a granite, No. 364. They show the feldspar enlargements. *a* shows cleavage lines passing from the original crystal into the added portion. *c* is from No. 268, a pegmatite which approaches a granophyre in structure.

by the original crystal, and therefore would all extinguish alike, and when in the process of growth they finally coalesced they would form but one individual. It is perhaps not improper to look upon the rays of the micropegmatite border as being crystal skeletons produced under conditions unfavorable for the completion of the entire individual crystal.

These enlargements have an important bearing on the question of the structure of the granites in which they occur. The rocks from which the figures already referred to were taken have every appearance of being true granites. Number 302 is from a specimen picked up at Knob Luck, the shipping point for the Syenite quarries, from which place it is reported to have come. The specimen has a uniform texture, is of medium coarseness, and is composed of a large amount of a light-colored feldspar, but little quartz, and an unusually large proportion of biotite for the Missouri granites. Number 364 was sent me by Mr. Payne, and was reported to be from section 3, T. 33, N. R. 5 E. It is reddish granite, of uniform texture, and is tolerably fine grained. The most noticeable microscopic feature of it is the strong resemblance in shape of the original orthoclase crystals to the lath-shaped feldspars in diabase.

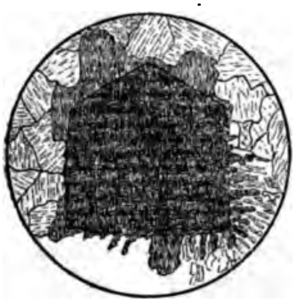

Fig. 3.
x 40 diameters.
From a granite No. 302. This shows an idiomorphic orthoclase partly surrounded by a secondary growth, and partly by a micropegmatite in which the feldspar is attached to the original crystal and oriented with it.

The original crystals are usually much more decomposed than the secondary zones. Other slides show the same kind of enlargements, but these two are the best examples.

Two different explanations for these phenomena might possibly suggest themselves.

1° We may suppose the granites possess the "miarolitic" structure; that is, they so contracted in cooling that numerous cavities were formed throughout the mass. It would then be possible for certain crystals to project into such cavities forming a druse. Subsequently the cavities might be filled with

quartz and feldspar material,[1] the latter of which could arrange itself around the feldspar crystals so as to form secondary growths similar to those described by Van Hise.[2]

A careful study of these specimens however, shows a great improbability of the correctness of this explanation for these enlargements. There is not the slightest indication of the former existence of the miarolitic structure, or of druses formed from any cause. We must therefore look for another explanation.

2° We may suppose that in the process of cooling the feldspar crystals were formed and floated about in the magma for some time, as the porphyritic feldspars do in the magma of a porphyry. As the whole mass finally solidified these crystals attracted around themselves portions of the remaining feldspar material, and thereby were subjected to a second growth differing from the first principally in the irregularity with which it progressed.

This in reality is nothing more than a form intermediate between two well known phenomena; viz, the ordinary zonal structure in idiomorphic crystals on the one hand, and the phenomena resulting from the orienting influence of porphyritic individuals of quartz and feldspar, in the porphyries on the other.

A number of different investigators have already observed similar phenomena. In 1881 C. Höpfner[3] gave a description of certain zonal structures in the triclinic feldspar from Mt. Tajumbina, Peru, and according to his observations certain irregular developments of these produce forms somewhat similar to the secondary enlargements here described.

In 1882 Prof. G. H. Williams[4] described and figured certain zones around both quartz and feldspar in quartz-porphyry from the Black Forest, which he attributed to the continued growth of the crystals during the effusion period. They thus represent the same kind of enlargements found in the Missouri granites.

In 1883 Prof. Friedrich Becke,[5] in an article entitled, "Erup-

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[1] See Rosenbusch's Mass. Gest., 2nd ed., p. 39.

[2] U. S. Geol. Surv. Bul. 8. pp. 44-47.

[3] Neues Jahrb. Band II. 1881. p. 164.

[4] Neues Jahrb. Beilage-Band 2. pp, 605-607.

[5] Min. und petrog. Mitth. vol. 5. pp. 147-173.

tivgesteine aus der Gneissformation des niederösterrichischen Waldviertels," describes certain zones of feldspar material around plagioclase crystals which, if I understand his article, should be referred to a secondary growth during the second period of consolidation. The rock in which they occur is a kersantyte. He divides the constitutent minerals into two classes. The first class includes basic feldspar, biotite, augite, olivine and quartz. He says that they were formed before the solidification of the rock mass and correspond to the "éléments de première consolidation" of F. Fouqué and M. Lévy. The second class includes plagioclase rich in soda, orthoclase, quartz, and pale-green hornblende, and correspond to the "éléments de seconde consolidation" of F. Fouqué and M. Lévy. He then says: "These last constituents, which cannot be called secondary in the ordinary sense of the term, and which I have called constitutents of the second order, are at times most intimately associated with the above mentioned constituents of the first order; oligoclase and micropegmatite appear as zones of parallel growth around the andesine kernels of the first order,"[1]

Again he says: "The feldspar crystals [of the I order] are united with the 'Zwischenmasse' [the material of the II order] by means of the oligoclase zones,"[2] and further; "Also the oligoclase zones pass directly over into the micropegmatite, as is shown by the fact that the feldspar in the same extinguishes with the oligoclase zones of the adjacent feldspar crystal."[3]

In the same year Karl Bleibtreu,[4] in a paper entitled, "Beiträge zur Kenntniss der Einschlüsse in der Basalten, mit besonderer Berücksichtigung der Olivinfels Einschlüsse," describes

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[1] p. 170. "Die letzteren Gemengtheile, die man nicht als secundär im gewöhnlichen Sinne des Wortes bezeichnen kann, die ich deshalb als Gemengtheilen II Ordnung bezeichnen werde, sind mit den fruher angefuhrten Gemengtheilen I Ordnung zum Theil auf das Innigste verbunden; Oligoklas und Mikropegmatit erscheint als parallel fortgewachsene Hulle um die Andesinkerne I Ordnung."

[2] "Die Feldspathkrystalle sind mit der Zwischenmasse durch die Oligoklashulle verbunden."

[3] "Auch setzen sich die Oligoklashullen häufig direct in Mikropegmatit fort, was daran erkannt wird, dass der Feldspathgrund desselben gleichzeitig mit der Oligoklashulle benachbarten Feldspathkrystalle auslöscht."

[4] Zeitschrift der deutsch. geol. Gesel. 1883. vol. 35. pp. 489-556.

numerous instances in which feldspar and other minerals have been partially fused by the basalt lava, and on cooling have had secondary rims attached which were oriented by the original crystals. They would thus be true secondary enlargements produced in precisely the way suggested above for the Missouri granites.

In April of the same year E. Hussak,[1] in a paper entitled "Ueber den Cordierit in vulkanischen Auswürflingen," describes the same kind of occurrences, in substance, as there mentioned by Bleibtreu. In 1884, C. Doelter and E. Hussak[2] published an account of some very interesting experiments made by fusing different kinds of natural volcanic rocks and observing the effect the fused mass had upon natural crystals of feldspar and other minerals. Portions of the crystals were dissolved and, upon cooling, re-crystallized in the form of grains and lath-shaped crystals which were oriented by the original crystal, often grading into it in such a way that no well defined line was left between the two.

In 1887 Dr. Max Koch[3] described feldspar enlargements in kersantyte which he thinks could best be explained by attributing them to secondary growths of the original crystals from the molten magma.

Rosenbusch, in the last edition of his great work, vol. II. p. 341, mentions such enlargements in a general way, but gives no specific descriptions, and no references to the literature of the subject. On page 360 he mentions the work of Dr. Williams above given. Of course this kind of enlargement is entirely different from those in fragmental rocks described by Irving and Van Hise[4] for quartz, and by Van Hise[5] for orthoclase and hornblende.

Before describing topaz it will be well to speak of the changes which have taken place in the wall rock of the vein at the locality known as the "Silver Mines." The vein itself extends from the west bank of the St. Francois, back in a south-west direction for an unknown distance. Years ago mining opera-

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[1] Issued with above litle; also vol. 87 der Sitzb. der k. Akad. der Wissenschaft, 1883. I. Abth. April Heft.

[2] Neues Jahrb., 1884. I Band, pp. 18-44.

[3] Jabrbuch der k. Preuss. geol. Landesanstalt, 1887, pp. 77-78 and 98.

[4] U. S. G. S. Bul. 8.

[5] Am. J. Sci. vol. 30. pp. 233-235.

EXPLANATION OF PLATE I.

Fig. 1. The pœcilitic structure in quartz-porphyry. As the thin section is revolved between crossed nicols the field breaks up into different areas, which extinguish differently, so that in any one position one area will give its maximum amount of light, another its greatest darkness, and others intermediate degrees.

From No. 211, north side of Shepard mountain, three-fourths way up from the base. Magnified 44 diameters.

Fig. 2. Pseudospherulites with orthoclase nuclei. The microgranitic portion is composed of quartz and feldspar.

From No. 410, the wall rock of the big diabase dyke at the "Tin Mines." Magnified 44 diameters.

Fig. 3. The "pœcilitic" structure in quartz-porphyry which is much more coarsely crystalline than that shown in fig. 1. Three quartz crystals are represented, each of which has a very large surrounding area that really is a portion of the central crystal, but spotted over with feldspar material. One of the crystals has a number of small but well formed orthoclase crystals projecting into it. The areas which do not have central crystals are similar to the others, and consist of a quartz ground-mass with the feldspathic material scattered through it.

From No. 347. Magnified 30 diameters.

Fig. 4. Augite with a secondary green hornblende rim around it; biotite with a hornblende crystal enclosed, and also with magnetite scattered regularly through it; plagioclase, and beautiful micropegmatite.

From No. 235, a coarse-grained quartz-diabase. Magnified 30 diameters.

Fig. 5. Porphyritic primary quartz, a, and secondary quartz, c, with a chloritic core. The primary quartz, a, has a reactionary rim around it of almost uniform breadth, the result of a corrosive action of the molten magma upon the quartz.

From No. 336, a fine-grained diabase-porphyryte. Magnified 30 diameters.

Fig. 6. Diabase porphyryte with glass carrying trichites and crystal skeletons. The plagioclase is shaded with parallel broken lines; the augite with small crosses.

From No. 415, taken at the big dyke at the "Tin Mines." Magnified 44 diameters.

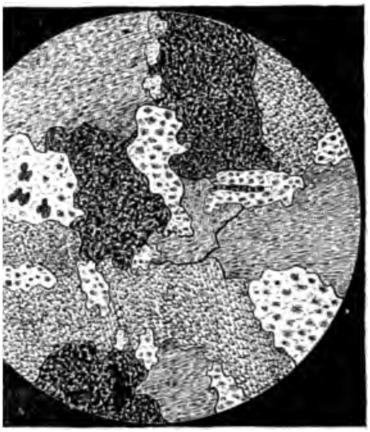
Fig. 1.

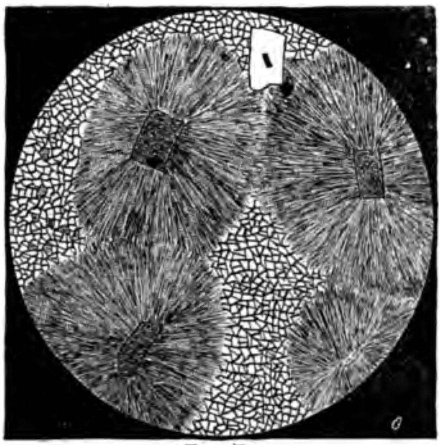
Fig. 2.


Fig. 4.

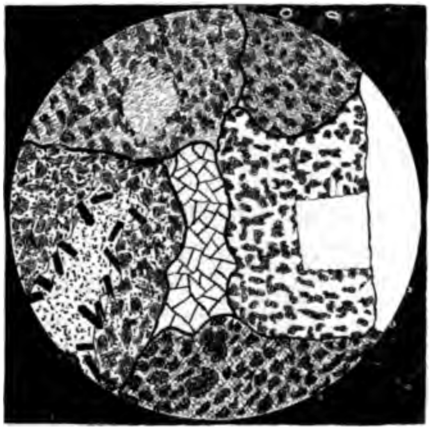
Fig. 3.

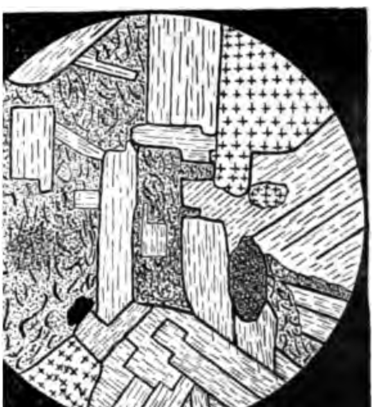
Fig 6

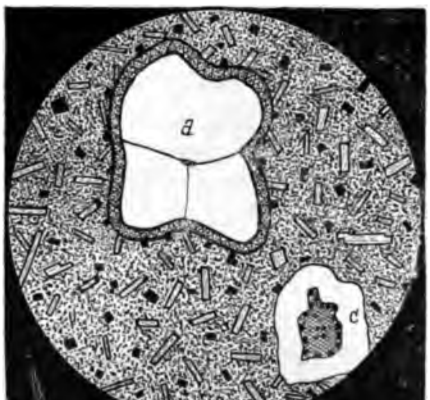

Fig. 5.

tions were carried on in an almost fruitless search for silver. At the time of my visit to the place the works were abandoned, the shafts and tunnels filled with water, so that almost the only available material was in the "dump pile." A fourth of a mile back from the river a shaft had been sunk upon the vein and named the "Apex shaft." The vein itself was filled with quartz, argentiferous galena, fluorite, lepidolite, wolframite, and probably other minerals. The wall-rock was originally granite. At present, however, it consists of quartz imbedded in a fine-grained mixture of mica scales with traces of iron oxide, leucoxene, beautiful little zircon crystals, and probably other materials. Scattered through this mass in varying proportions are the minerals fluorite and topaz.

We evidently have here the results of a fumerole action, recalling in some respects the conditions around the tin mines of Cornwall, Eng., of Zinnwald in Bohemia, and those of other places. The resemblances consist in the granite wall-rock being decomposed for a few feet on each side of the vein, and the occurrence of topaz, wolframite, lepidolite and fluorite, minerals which are associated with tin ores in other places. But so far as now known there is a total absence of cassiterite, as well as of tourmaline, and other minerals—excepting those just given—which always accompany tin deposits.

Topaz.—In all the thin sections examined from the wall-rock of the vein just described a considerable quantity of a mineral thought to be topaz was found. It does not have a regular crystalline form, but in many cases the direction of the crystallographic axes could be determined. Its index of refraction, as shown by its apparent thickness, its parallel extinction, and its polarization colors strongly implied that the mineral in question was topaz. Portions of it were isolated by first making a separation with the Thoulet solution, sp. gr. 3.12, and then treating the powder thus obtained with the strong, hot acids. This dissolved everything but the mineral in question. Each of the three acids was tried in turn, and finally aqua regia, but after boiling no less than an hour the little grains were unaffected. A blow-pipe examination with the salt of phosphorus proved it to be a silicate. There can be little doubt, therefore, that the mineral is topaz.

(c) Structure of the granites.

The granites from Graniteville, Syenite, Stout's creek, and the St. Francois river are moderately coarse-grained, of a pink color which varies considerably in shade, and are generally mottled with biotite or hornblende. At Graniteville and Syenite very extensive quarries are worked, which produce grades of granite equal in appearance to the New England granites. In localities different from the ones named the granites have a finer texture, and grade off into the porphyries.

It may well be said that in but few instances do we find granites which do not in some degree possess a structure approaching the porphyritic. That from Graniteville shows it the least. Those along Stout's creek and the St. Francois have it much more developed. The hornblende, when present, is always idiomorphic, and the feldspar, biotite and quartz are to a considerable extent. The well formed crystals of quartz in number 303 has already been mentioned. The feldspar enlargements have an important bearing here. They show unmistakably that there were two distinct periods of solidification, and consequently that the only difference between the structure of the granites and the overlying porphyries is in the character of the product of the second period of solidification.

As we pass back from the low ground we invariably find the texture of the granite becoming more fine, and in every respect more closely resembling the porphyries and felsytes. The structure of the rocks intermediate between the granites and the porphyries can best be considered after the porphyries have been described.

(d) Classification of the granites.

As has already been stated the granites are all very similar in mineralogical composition. There are but three different varieties which are sufficiently distinct to be given separate names. The first of these is composed wholly of feldspar and quartz, excepting the few unimportant accessory minerals which may occur in all granites. From its intimate associations with biotite granite we must look upon it as being a facies of the latter. The third variety has a small amount of hornblende, but by no means a sufficient amount to bring it under

the general division of amphibole granite of Rosenbusch. Following Rosenbusch's classification we shall therefore have the following:

$$\text{Granite}\begin{cases}\text{Granite (feldspar and quartz).}\\ \text{Granitite.}\\ \text{Hornblende bearing granitite.}\end{cases}$$

(To be continued.)

THE REEF-BUILDERS.

BY DR. LEWIS E. HICKS.

What is the true theory of coral formations? Half a century ago Charles Darwin proposed the subsidence theory; half a dozen years ago John Murray proposed the abrasion and solution theory. Darwin accounts for the great thickness of the reefs by a sinking of the foundation as fast as the polyps built upon it. Murray supposes that the reef, beginning within the bathymetric life-limit of the polyps, first grew up to the surface, then, by constant abrasion of the waves, became a factory for the production of coral *debris*, and thus grew into deep water upon the talus of its own fragments, the dead landward, or inner portion (if it was an atoll), being at the same time dissolved away by the sea water.

Two paths are open to us in the treatment of these theories. We may either set them the one over against the other in an antagonistic and exclusive sense, try to choose between them, and then try to coërce all the facts under the theory of our choice; or, realizing the complex nature of the phenomena and the possibility of some truth in both theories, we may bend our energies to the task of discriminating, sifting, discovering what kind of structures each theory will explain most satisfactorily. The latter path may not be the easier one, but it is certainly the more rational.

At all events let us not here in America become heated partisans of either Darwin or Murray. American geologists have no occasion to take sides in the personal aspects of the controversy provoked by the duke of Argyll in his "Great Lesson" contributed to the September number of the "Nineteenth Cen-

tury." It is true that all the parties concerned, professors Huxley and Judd on the one hand, and the noble duke on the other, are highly esteemed on this side of the water, but whether peer or commoner shall prove to be wholly right, or both considerably in the wrong, is not a vital matter to us. In respect to the duke's charge that scientific men are given to idolatry, and guilty of suppressing truths which might topple their Dagon (or Darwin) to the earth, we see too many examples of the fierce zeal of young naturalists to win their spurs by knocking old ones on the head, to give that charge much credence.

But as to the example brought forward by the duke to enforce his "Great Lesson"—the true theory of coral formations—we do take a deep interest in that. We want to know how coral reefs and islands are actually formed, no matter who may suffer or gain in reputation, by the establishment of the truth. Holding this judicially impartial attitude we shall be better qualified to discriminate and to reach a just conclusion than those who have permitted their emotions to mingle with and obscure their perceptions and judgments.

In the bald statement of the two theories, as above, there is truly little or nothing to discriminate. But each theory is really a great complex of facts and interpretations in which there is much to discriminate. Especially in the application of the theories to the facts is the great complexity of the problem, and the need of careful distinctions apparent. The radical fault of theorists is too frequently seen to be wholesale generalization—"brilliant" generalization, perhaps, at least in the eyes of their admirers, but none the less wholesale and untrustworthy. The assumption that all coral formations are subject to the same law, that there must be *a* theory of coral reefs and islands, is an error of this kind. It is quite conceivable that one law of growth may determine the form of some reefs, and a different law may apply to others; in other words there may be two or more true theories of coral formation, instead of one.

Why should coral reefs require any special explanation? Are they not simply examples of ordinary organic sediments, such as have been forming all through geological history? Take any one of the old limestones and inquire how it was made. Was it not by the accumulation upon some sea-bottom

of the calcareous matter secreted by certain animals? And what else is the coral reef? The polyps take up carbonate of lime from the water and build it into masses of coral which are then broken, triturated and pulverized by the waves, and finally deposited like any other sediment.

In answer to this three reasons may be given for removing coral formations from the category of ordinary calcareous sediments. In the first place the limited range in depth—the bathymetric limit—of the polyps, imposes peculiar conditions. Secondly, the polyps are true reef-builders. Sediment is something that *settles down*; the reefs are *built up*. Not the whole of the reef indeed, but certainly that portion between the depth of 120 feet[1] and the line of wave action is a genuine *building* of which the polyps are the architects and masons. In the third place, the pure calcareous matter, when it has been comminuted by the waves, hardens with such rapidity as to introduce a new and distinguishing feature in sharp contrast with ordinary sedimentation. This facilty in passing from the condition of incoherent fragments to that of firm and complete consolidation, has two notable results. It prevents that dissipation of the rock material over wide spaces which would necessarily follow if solidification were long delayed; and it produces steep slopes instead of the horizontal planes which are characteristic of ordinary sediments. Even the loose coral sand will lie at almost as high an angle under water as dry sand in air. I have ascertained experimentally that the average resting slope of fine dry coral sand is 35°, and Prof. Agassiz observed slopes of 33° composed of coral sand under water.

But notwithstanding these three good reasons for separating coral reefs from ordinary sediments it is certain that, in many cases, the best light in which to study them is that which is furnished by the ordinary laws of sedimentation. The Florida reefs, for instance, have been shown by Prof. Alexander Agassiz to owe their form and their extension westward to the action of tides and currents which shape the calcareous sedi-

[1] There is much variance in the statements of the depth at which the reef-building species will live. Undoubtedly they will live much deeper in some seas than in others. I give the figures 120 ft. as a general average.

ment just as any sandspit is shaped. A counter current to the gulf stream sets into the gulf from the Atlantic, carries the coral *debris* along with it, and spreads it out in a long curved tongue in the line of the Keys. The coral sand soon hardens, and upon the foundation thus furnished the polyps take root (at a depth no greater than 42 feet in this region) and build up to the level of low tide where the waves take up and finish the work.

Such is the statement of Agassiz, who discredits the subsidence theory of Darwin. But, in order to make good my claim that there is no dispute about the essential facts, I quote from Prof. James D. Dana, the most illustrious advocate and expounder of Darwin's theory. "The facts presented by lieutenant Hunt, and more fully by Mr. Agassiz, with regard to the effects of the eddy current of the gulf stream, show that coral reefs may be elongated, and also that inner channels may be made, by the drifting of coral sands. But the action with coral sands is essentially the same as with other sands; and illustrations of this drifting process occur along the whole eastern coast of North America from Florida to Long Island. We there learn that drift-made beaches run in long lines between broad channels or sounds and the ocean; that they have nearly the uniform direction of the drift of the waters, with some irregularities introduced by the forms of the coast and the outflow of the inner waters which are tidal and fluvial and have much strength during ebb tide. The easy consolidation of coral sands puts in a peculiar feature, but not one that affects the direction of drift accumulation." [2]

Dana corroborates Agassiz fully in regard to the facts, but later in the same article he draws the inference that there has been "a great subsidence" in the reef region of Florida aud the West Indies. This inference encounters serious obstacles. Several concentric reefs form the southern extremity of the peninsula. They are thin reefs; their summits are all about at the same level; they seem to have been formed succesively, not simultaneously; and lastly the process and method of their formation without subsidence seems to have been fairly demonstrated by observation on the spot.

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[2] Am. Journal of Science, Sept. 1885 p. 178.

But the Florida reefs are perhaps the least favorable to the Darwinian theory of any that could be selected. How is it possible, without subsidence, to account for some of the reefs of the Pacific ocean, which are five or ten times as thick as the Florida reefs? The reef along the north shore of Tahiti, having a thickness several times the depth at which the reef polyps will live, may serve for a test of the two theories as applied to a thick reef. This is a barrier reef three fourths of a mile from land. The lagoon channel is not too deep for polyp-life, so that the reef may have begun where its inner base now rests. There is no need of invoking the solvent action of sea water to account for the depth of this lagoon. All the interest is concentrated upon the seaward face of the reef, of which the accompanying illustration (fig. 1) will give a better notion than can be conveyed by words.

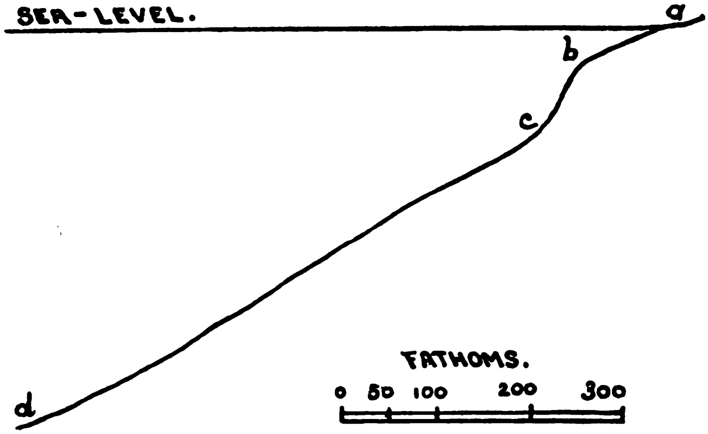

Fig 1. Diagram of seaward face of the barrier reef at Tahiti, on a true scale vertical and horizontal. After Murray. (A portion of the reef below d is omitted. The slope diminishes to 6° at the bottom of the portion omitted).

a to b, slope of 18° with colonies of living coral polpys.

b to c, talus of large blocks (some 20 and 30 feet long) of reef rock. Average slope 45°, maximum slope 75°.

c to d, slope of 30° composed of coral sand.

Depth at b, 40 fathoms, at c, 100 fathoms, at d, 425 fathoms.

Horizontal distance from a to b, 250 yards, from b to c, 100 yards.

Murray maintains that the slope from a to b is the great laboratory for the production of reef matter, all below being

simply a mass of *debris*, of which the very coarse and angular fragments form the steep slope just below the zone of living corals, and the finer sand forms the gentle slope down to the seaward base of the reef. Dana corroborates the facts, and remarks that they "sustain instead of correcting those announced by earlier observers. Beecher and Darwin make the mean slope about 45°, and my report says 40° to 50°."[1] But he maintains that the talus of large blocks from 40 to 100 fathoms is "positive proof of much subsidence" because it is "far below the limit of forcible wave action." This is not conclusive. These blocks have descended by falling or sliding down the sea-ward face of the reef—how far may be doubtful, possibly from any part of the slope a b. If they have descended at all their present depth below the line of any wave action forcible enough to break them off does not appear to furnish the positive proof of "*much subsidence*" which is claimed for them. Dana has himself stated that when subsidence is not in progress "the coral and shell material produced that is not lost by currents, serves to widen the reef and to steepen in consequence of the widening, the upper part of the submarine slopes." The tendency of this action would be to broaden the life zone a b, until it became very steep or even overhanging at b, like the "coral heads" described by Whipple and Hartt.[2] In that case no very forcible wave action would be required to dislodge the huge blocks which form the talus b c. Tahiti has not been subsiding, but rather rising, in recent times, as shown by the breadth of shore plain underlaid with coral somewhat above sea level. If we grant that the talus of large blocks does not prove subsidence, then there is no evidence of it known to me, except that the Darwinian theory demands it.

Plainly the Tahitian reefs may have been formed without subsidence. The seaward slope is not too steep for the possibilities of debris-accumulation in deep and, therefore, quiet water. The part composed of coral sand is even less steep than slopes of the same material observed by Agassiz at the Florida Keys. In the steepest part the fragments are coarse and angular, and the cementing effect of the calcareous matter

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[1] Am. Journal of Science, Sept. 1885, p. 175.

[2] See Corals and Coral Islands. Dana pp. 139, 141.

filling the interstices as fine sand and precipitated from solution in the sea, would help to form and maintain a steep face. The position of the talus just beneath the zone of living corals accords with Murray's theory. In fine the facts are against subdivision as a *necessity* in the explanation of thick reefs.

But while thickness of coral reefs is not in itself a positive proof of subsidence, there may be other attendant circumstances which do constitute good evidence of it. If, for instance, a reef is very thick and at the same time very steep in the lower part of its sea-ward face (about the region d in fig. 1) we may reasonably infer subsidence. "Seven miles east of Clermont Tonnere the lead ran out to 1145 fathoms (6870 feet) without reaching bottom. Within three quarters of a mile of the southern point of this island the lead, at another throw, after running out for awhile, brought up an instant at 350 fathoms, and then dropped off again and descended to 600 fathoms without reaching bottom. On the lead, which appeared bruised, a small piece of white coral was found, and another of red."[1] This sounding indicates vertical or overhanging walls at great depths. Several examples of the same kind are on record, and are good evidence of subsidence, although such wall-like steepness is quite exceptional. Great thickness of a reef on the inner or lagoon side is also good evidence of subsidence, at least until we have more complete proof of the adequacy of Murray's solution theory. Dr. Archibald Geikie, who in other respects accepts Murray's views, doubts the competency of sea water to dissolve such vast masses of limestone as must have been removed in some cases. Prof. Carl Semper accounts for deep lagoons by the scouring action of tides and currents, but Dana replies that the waters can scour only to the depth of the outlet from the lagoon to the sea, which is sometimes of less depth than the lagoon. Deep lagoons, therefore, seem to present the strongest case for the Darwinian theory.

Atolls are placed by Darwin at the end of a series, beginning with the fringing reef, then the barrier reef, then the atoll; and upon that supposition they must always have been preceded by subsidence. Dana accepts this view, and makes it the basis of

[1] Dana. Corals and Coral Islands, p. 171.

his reasoning in locating the line A A ("the axial line of this great Pacific subsidence") upon the Physiographic Chart at the end of his Manual of Geology. Murray maintains that atolls are no more to be taken as evidence of a sinking bottom than other coral formations. They begin upon submarine banks within 120 feet of the surface and assume the circular form simply by reason of the vigorous growth at the periphery, and the dwindling or death of the polyps nearer the center. Even Darwin admits this explanation as a possibility. The foundation for the atoll may be a hidden rock or the accumulations of pelagic life upon the higher parts of the sea floor, raising them within reach of the reef-builders.

Prof. Semper has long maintained that the atolls of the Pelew group not only fail to prove subsidence, but that the facts are all against Darwin's interpretation. Instead assuming subsidence as a necessity he claims that "the problem ought in each case to be determined by actual detailed observation." That a given reef region may have subsided, and that the reefs do in that case owe their form largely to the fact of subsidence, he is quite ready to admit, and so are all the anti-Darwinians. But they insist that subsidence is not a *necessary* condition of the problem, and hence that atolls do not simply by virtue of their presence prove a downward movement of the region in which they occur. If such a movement has occurred then the atoll may very well be the last term of a progressing series, as Darwin supposed, but the whole series cannot be inferred from the existence of the atoll.

Darwin should not be held responsible for the views of his followers, unless they were his own. It would be a delicate and thankless task, however, to attempt to draw the line between his real opinions and the exaggerations of his followers. Without attempting any such distribution of praise or blame I am constrained to remark that the impressions produced upon the reader by most of the current geological literature are misleading, and the discussion now in progress was needed in order to clear our vision. For an example I will refer the reader to an excellent book, Prestwich's Geology,[2] recently published.

[2] Geology, Chemical, Physical and Stratigraphical. By Joseph Prestwich, Oxford, 1886.

Read the paragraph entitled "Surrounding Depths," (vol. 1, p. 237) together with the comparison in the next paragraph of the barrier reef of Australia to "a great submarine wall fronting the sea," rising "at its seaward edge from depths which certainly exceed 1800 feet,"and farther on "such is the nature of these wonderful growths rising up in the midst of the great oceans," and see if the mental picture is not that of huge vertical walls standing up in the waters. That is the tone of all the text-books. Who would ever imagine, if he had access only to such descriptions, that the actual average slope is no more than 45 degrees, and often as low as 30 degrees? Prestwich goes beyond Darwin or Dana in the sweeping inference of subsidence based upon the presence of coral formations. In his map, page 235, he colors every reef region as a sinking area, no matter whether the formations are fringing reefs, barrier reefs, or atolls.

We may conclude:

1. That thin reefs, such as those of Florida, give no support whatever to the theory of subsidence.
2. That thick reefs may be formed either with or without subsidence.
3. Atolls also may be formed on a stable as well as on a sinking platform.
4. Deep lagoons, or steep slopes fronting the sea in deep water, cannot well be explained without subsidence.

A CORRELATION OF THE LOWER SILURIAN HORIZONS OF TENNESSEE AND OF THE OHIO AND MISSISSIPPI VALLEYS WITH THOSE OF NEW YORK AND CANADA.

BY E. O. ULRICH.

(*Continued from p. 190.*)

A digest of the preceding list is as follows:[1]

Total No. sp. mentioned from beds XI, XII, XIII, XIV	..450;	restricted to same,	392
" " " " " XI	..........................186;	" "	108
" " " " " XIa	..........................133;	" "	40

[1] Certain errors in the range of the species given in the preceding table should be rectified. The species are referred to by their numbers. Thus, 49 is restricted to XII *a*, instead of XII *b*; 78 also in XII *b*; add as

Total No. sp. mentioned from beds XIb ....186; restricted to same, 41
" " " " " XII ....199; " " 113
" " " " " XIIa ....142; " " 57
" " " " " XIIb ....121; " " 46
" " " " " XIII ....141; " " 60
" " " " " XIV ....91; " " 27
Species common to XIa and XIb 80
" " " XIIa " XIIb 58
" " " XI " XII 52
" " " XII " XIII 46
" " " XIII " XIV 57
Total No. of species passing from beds XIa into and not beyond XIb 37
" " " " " XI " " " XII 20
" " " " " XI " " " XIII 7
" " " " " XI into.......... XIV 24
" " " " " XIIa into and not beyond XIIb 24
" " " " " XII " " " XIII 20
" " " " " XII into.......... XIV 30
" " " ranging through all the beds from XIa to XIV,.....23 (2 doubtful)
" " " passing up from lower beds and ranging through..........18
" " " " " " " into beds XI or higher, 58 (4 doubtful)
Of these 58 species 22 are not known above beds .... *XI*
3 occur in beds *XI* but are last met with in beds .... *XII*
8 " " *XI* and *XII* but are last met with in beds .... *XIII*
6 " " *XII* but are not known in beds .... *XI, XIII, XIV*
1 occurs " *XIII* and *XIV* but is not known in beds .... *XI* and *XII*
1 " " *XIV* but is not known in beds .... *XI, XII*, and *XIII*

We will now proceed to consider these beds more in detail.

Beds XI. This division is about 300 feet thick at Cincinnati, Ohio, and consists mainly of shales separated at intervals varying between 2 inches and 6 feet, by mostly thin layers of limestone. The latter vary in thickness from 1 to 24 in., yet are rarely more than 6 in., and commonly less than 4 in. In general terms they may be described as drab to bluish, sub-crystalline, even bedded, firm limestones, usually charged with fossils. The drab courses are somewhat sandy and in them fossils are rather scarce.

The shales vary both in color and firmness, those met with in the lower portion of the division being harder and their bluish tint less decided than that of those which constitute the bulk of the middle and upper portions of the section.

These beds as they are exposed in the vicinity of Cincinnati, admit of being again divided into two subdivisions, which may be designated, as *a* and *b*. In the following careful description of their peculiarities, I shall endeavor to show that they are dis-

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85 *a Lichenocrinus crateriformis* Hall in columns L. B, XI *a*, and XI *b*; 87 also in XI *b*; 91 and 92 range up from column L. B; add as 121*a Heterotrypa? vaupeli*, in XII *b*; 126 occurs in XI *a*, XI *b* and XII *a*: 203 also in XIII; 240 occurs apparently only near top of XII *a*, and not in XII *b*; 245 should read *G. schuchertana* Ulrich; 266 and 297 also in XII *a*; 311 also in XIV; 328 in XII instead of XIV; 362 in XI *b* instead of XII *a*; 391 in XII *b* instead of XII; *a* 395 also in XIII; 442 and 443 in XII *b* instead of XIII; 444 in XII *a* instead of XII *b*; 448 in L. B. and XI *a*.

tinguished by recognizable, though slight, changes in both their lithology and fauna.[1]

a The thickness of this subdivision in the vicinity of Cincinnati is between 75 and 80 feet, but only 50 of these are exposed in the Kentucky bank of the Ohio river opposite the city, the lower 25 or 30 feet being below low water mark. In going up the river, however, more and more is brought to the surface, till near Point Pleasant the whole thickness may be seen. The character of the lower 15 or 20 feet in the Ohio river exposures is not fully established, and I can speak of them only in the light furnished by well-borings at Covington and Cincinnati.[2] These appear to show that they are composed of dark shales, and twelve or more 3 to 8 inch courses of either subcrystalline or impure hard limestones, the latter apparently the more numerous. Both the shales and limestones contain an abundance of trilobite remains, of which those belonging to two or three species of *Asaphus* are by far the most numerous. The valves of several species of *Beyrichia*, *Primitia* and *Cytheropsis* are also very numerous, but other fossils seem to be rare.

Several of the well-borings at Cincinnati seem to show that the contact between beds X and XI *a* is well marked, the passage of the drill from the shaly layers of the latter into the tough heavy-bedded limestones of the former being abrupt. Still, I am inclined to believe that to the south and east of that city some localities will be found where the passage from the one into the other is not so abrupt. Such a locality probably exists along the Kentucky Central R. R. not far north of Paris, Ky. Carloads of rock brought from that vicinity and used for ballast by the Ky. Central R. R. Co. certainly resemble some of the layers of XI *a*. The rocks are full of fossils, of which among others characteristic of beds XI *a*, *Orthis borealis* Billings and *Rhynchonella increbescens* Hall, have not been found above beds X in central Kentucky.

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[1] It is to be observed here that XI*a* is nearly equivalent to the River Quarry beds, and XI*b* to the Eden shales of Prof. Orton (Geol. Surv. of Ohio, vol. I)

[2] The writer hopes soon to make a careful examination of the Point Pleasant section so as to determine, if possible, the exact position of the strata there exposed.

The best exposure of this subdivision known to me is found in the Kentucky bank of the Ohio river, beginning about one mile west of the mouth of the Licking river. Here every layer of the upper 50 feet may be traced for nearly a mile, and, on account of the frequent washings to which the beds are subjected by the rising of the water in the river, many fine fossils are annually collected there.

At this locality the uppermost member of the series is formed by a crinoidal limestone layer, varying in thickness from 1 to 2 feet and composed almost entirely of the comminuted remains of *Heterocrinus*. The upper surface of this layer is rough and generally presents a mottled appearance due to small lenticular concretions, often charged with iron, which are contained in it. A large branching species of *Ptilodictya* which I propose to name *P. ponderosa*, is apparently restricted to this layer. The branches of this bryozoan are often more than an inch in width, and nearly a quarter of an inch in thickness.

Immediately beneath the heavy layers there is a little soft shale, and below this three or four feet of somewhat granular, unevenly bedded, limestones, which disintegrate rather rapidly and are disposed to break up into irregular layers on exposure to the weather. When freshly fractured, their crystalline interior is light blue in color, and contrasts strongly with their gray or brownish exterior. It is from them that the *Dendrocrinus dyeri* is derived. Specimens of this graceful crinoid are not rare, but, on account of the peculiar character of the rock, very few of them are well preserved. A singular feature relating to the occurrence of this crinoid is that the specimens are almost invariably attached to the lower side of the layers. Other fossils are rare, and except a *Lingula* (*L. norwoodi James*) always illy preserved.

Below these layers there are about 12 feet of a soft clayey shale and more evenly bedded impure limestones, when a layer holding numerous hard clay nodules is met with. Some of the limestones are highly fossiliferous, while the shale in places contains numerous fragments of *Monotrypella briareus*. Other fossils that are more or less abundant at this horizon are *Modiolopsis cincinnatiensis*, *M? cancellata*, *Lyrodesma planum*, *Pleurotomaria ohioensis*, *Bellerophon bilobatus*, *Lockeia seliquaria*,

Cyclophycus laterale, *Batostoma erraticum*, *Aspidopora? calycula*, *Ambonychia n. sp*, and *Tetradium fibratum* (rare.)

Two or three feet below the nodule layer there is a strongly undulated limestone, 3 to 10 inches thick, containing *Tellinomya alta*, in great abundance. From this layer to low water mark (about 18 feet) the section consists mainly of hard and softer shales, grayish or drab colored when weathered, and several courses of impure limestone. Aside from rather numerous fragments of *Asaphus* fossils are comparatively rare.

In going up the river to the mouth of the Licking the slight rise in the strata brings up about 4 feet more of the series. These consist of a number of courses of subcrystalline dark or grey limestone, four to six inches thick, separated by nearly the same amount of shales. The upper layer of limestone generally contains many good examples of *Modiolopsis cincinnatiensis*, while the lower ones are full of ostracoda, and hold also a considerable number of *Asaphus* fragments. The shale bands contain *Pterinea insueta*, *Lingula cobourgensis* and, one band in particular, great numbers of *Leptobolus lepis*. This same horizon is exposed several miles up the Licking river. Here they furnished also species of conodonts referable to *Deprano-dus*.

Several feet of shales that are *supposed* to represent the portion of the section immediately below that mentioned in the preceding paragraph are exposed under the bank of the river in the first ward of Cincinnati. They can only be reached when the water is very low, but as the river rarely fails to drop to the desired level at least once during the summer, this drawback is not very serious.

Several fossils occur in these shales that are not found elsewhere in the immediate vicinity of Cincinnati. *Triarthrus becki* which they contain in abundance, is probably their most important fossil; but none the less interesting are certain graptolites which have been found in them. These and other fossils that add interest to the beds are: *Graptolithus gracilis*, *Dicranograptus ramosus*, *Diplograptus spinulosus*, *Aspidopora areolata*, *A? newberryi*, *Leptæna plicatella*, *Lingula riciniformis*, *Leperditia radiata*, *Merocrinus curtus*, and *Stenocrinus? geniculatus*. A colony of *Palæaster finei*, comprising more

than one thousand individuals was found. These occupied the surface of a layer of the shale over a space scarcely 2 feet square. In Mercer, Boyle, Washington and other counties of central Kentucky, the contact between beds X and XI*a* is often exposed. At the base of the latter, though not often seen in places because of its easy disintegration, there is generally a layer of limestone, one foot or so in thickness, which usually contains some rounded limestone pebbles, a little iron, fluorspar, and worn fragments of shells and bryozoa. Resting upon this there may be several feet of thin hydraulic limestone, then 15 feet, more or less, of dark limestone, appearing thick-bedded in fresh cuts, but breaking up into small pieces when long exposed. These are largely made up of the zoaria of an undetermined ramose bryozoan, with now and then an example of a massive species of *Crepipora*. Between these bryozoa layers there is also usually included one or more irregularly bedded hard crinoidal limestones.

Overlying the bryozoa beds we usually find several feet of soft, drab slightly greenish shales containing hard concretionary masses and a few fossils, mainly *Monotrypella briareus*. Above these shales there is usually a thick layer of limestone, probable equivalent to the crinoidal layer which marks the top of the subdivision in the Ohio river exposures. This is supposed to be so from the fact that the superposed strata have the character of XI*b*.

Much study is still necessary before we can satisfactorily correlate the strata of XI*a* observed in the central Kentucky counties south of the Kentucky river with those exposed in the neighborhood of Cincinnati. One thing seems certain, and that is, that the lower or trilobite layers are entirely absent south of the Kentucky river. That some member is missing is already indicated by the decreased thickness of the subdivision, it having diminished to about half the thickness observed at Cincinnati.

In Washington, Mercer and Boyle counties none of the exposures seen by me exhibit any strata which could be regarded as representing the trilobite layers, nor can I find any mention of such in Mr. Linney's reports on the rocks of those and other counties studied by him. That these layers were carefully

searched for by him I cannot doubt since in a conversation with him, he expressed himself as greatly disappointed because of his failure to discover certain species belonging to this horizon in the counties in which he was engaged.

Nor is this horizon established in Fayette Co., but in going farther northward I have observed, but not studied, certain beds at Georgetown and Rogers Gap which may represent them. At the last locality, especially, the Cincinnati southern R. R. has made several extensive cuts which would, I believe; throw much light upon the point.

XI*b*. This sub-division is exposed in numerous runs and creeks that empty into the Ohio and Licking rivers in the vicinity of Cincinnati. The upper half forms the base of the hills surrounding that city and Covington and Newport, two cities directly across the river in Kentucky. Over three-fourths of the entire mass, which here has a thickness of 225 feet, is composed mainly of soft shales. These vary slightly in color as we go upward, being greenish-gray, drab or yellowish, for the first twenty feet and of various shades of blue throughout the rest. Limestones are few and generally thin in the lower ninety feet, more abundant and in heavier courses (3′ to 8′) in the succeeding forty feet. Above this horizon for forty feet or more the shales again predominate greatly over the limestones, the latter being generally less and rarely more than three inches thick and separated from each other by beds of shale three feet or more in thickness. From this horizon which is often marked by two six-to-twelve-inch layers, to the top of the sub-division, a distance of fifty feet, the limestones, though still thin-bedded, become more frequent, the separating shale being usually less than one foot in thickness. Both the shales and limestones in this portion of the section gradually assume a sandy character, but this is never so pronounced as in the lower portion of the succeeding division.

At the base of these shales and resting directly upon the heavy crinoidal limestone top of XI*a*, there are often about two feet of hard drab shales having a concretionary structure. These are unfossiliferous, but in the next ten feet quite an abundance of species may be found free or on the surface of thin limestones slabs. *Crepipora venusta* and *Stictoporella*

interstincta are two interesting bryozoa which occur at this horizon more frequently than at any other known to me.

At ten feet above the base (*i. e.* sixty feet above low water mark in the Ohio river at Cincinnati) I have in several instances found a thin layer which is remarkable because it contains, besides large numbers of that small shell *Leptobolus insignis*, a number of fossils which are otherwise known only from the shale beds that have been described as occurring under the river bank in the first ward of Cincinnati. These fossils are *Merocrinus curtus*, *Leptæna plicatella*, *Triarthrus becki*, *Primitia bivertex* and *Cytheropsis unicornis*. The same layer is apparently represented in Taylor's creek east of Newport, Ky., where it is also about sixty feet above the bed of the Ohio river.

The five species above mentioned ought perhaps to be counted as common to XI*a* and XI*b*, but as they are characteristic fossils of the former and as none of them are known to extend higher in the series than stated, they have not been so regarded, but in the list are noted as restricted to the lower sub-division.

In the succeeding twenty feet very few fossils excepting trails, tracks and so-called fucoids, occur. The latter, however, are moderately abundant and better preserved than at any subsequent horizon in the Lower Silurian strata under discussion.

At about eighty feet above low water mark[1] (thirty feet above the top of XI*a*) fossils once more become abundant, bryozoa being predominant here as they are at all subsequent fossiliferous horizons in the sub-division. From here on to 180 feet above the river, fossils of that class increase in number until from the last mentioned level to twenty feet above they may be said to literally fill the shales. Where these layers are exposed to the weather the surface of the ground is found thickly strewn with generally well preserved fragments. These belong to many species, but as by far the most of them belong to three species of *Dekayella* (*D. ulrichi*, *D. obscura*, *D. n. sp.*) the layers might be appropriately called the *Dekayella bed*. *Orthis multisecta*, *Monotrypella æqualis*, *Batostoma jamesi*, *B. implicata*, *Callopora sigillaroidea*, *Ceramoporella distincta*, *C. ohio-*

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[1] When this expression is used, without being otherwise qualified, it refers to low water mark in the Ohio river at Cincinnati, O.

ensis, *Diamesopora communis*, and *D. vaupeli*, are also very common at this horizon.

Before going farther I desire to mention two other interesting fossil horizons. The first, about 120 feet above low water mark, afforded fine examples of *Tæniaster flexuosa*, *T. fimbriata*, *Palæaster finei*, *Palæaster n. sp.*, *Trinucleus concentricus*, *T. bellulus* and *Serpulites dissolutus*, all species that are considered rare. Three feet below this bed another contained many specimens of fossil worms in excellent preservation which have been described by me under the names *Protoscolex covingtonensis*, *P. ornatus* and *Eotrophonia setigera*.[1] Associated with these in extreme abundance were complete examples of an exceedingly delicate jointed bryozoan (*Arthrostylus tenuis*).

The second bed is about thirty feet above the star-fish layer, in a small run one-fourth of a mile south of Lewisburg, a suburb of Covington. Here several inches of the shale are crowded with graptolites belonging almost entirely to the species which I have named *Inocaulis arbuscula*.

At the top of the Dekayella bed there comes in a large form of *Callopora sigillaroidea*. An occasional fragment of *Constellaria florida* var. *prominens* is also met with here, but in the succeeding fifty feet this strongly marked variety becomes, at any rate at certain localities, very common. At 260 feet above low water mark the majority of the bryozoa observed in the Dekayella bed reappear abundantly in a bed three or four feet thick. This brings us to the top of the sub-division which is marked by an increase in the limestones and in the sandy character of the strata.

Little is known of the eastern and western extensions of this bed of shales, but there is scarcely any reason known to me why they should be found materially different from the Cincinnati section above described. To the south and beyond the Kentucky river some variation may be looked for, but this, it has been ascertained is not greater than has taken place in the southern extension of XI*a*.

In Boyle, Washington, Mercer and other counties of Kentucky, the lower eighty feet or more, the same as at Cincinnati, consist mainly of soft shales, the limestones being thin and

[1] Jour. Cin. Soc. Nat. Hist. vol. 1, p. 187.

widely separated, with bryozoa the principal fossils. Above these there are seventy or eighty feet more of shales and limestones, differing from the preceding eighty feet in having the limestones, especially in the lower part, heavier and the shale bands thinner.

This portion of the section contains several "wave layers" like those that occur in the same beds at Cincinnati. The upper one, which in central Kentucky comes in at about 170 feet above the top of beds X, is a marked feature at many localities in Washington and other counties.

Above this wavy layer there is a succession of limestones and shales 100 or more feet thick, the limestones, occurring in courses from two to eight inches thick, being generally impure, but in some cases semi-crystalline. The shales are more or less sandy and form beds of from two to twenty feet in thickness. The sandy character of the strata increases toward the top causing some difficulty in drawing the line between this division and the arenaceous base of beds XII.

Fossils belonging to the same species as those mentioned in the description of the Cincinnati exposures are very abundant in both the shales and limestones, particularly so at several horizons in the lower and middle thirds of the sub-division. In these they are also well preserved and readily washed from the matrix; but in the sandy upper layers they are neither so well preserved nor so plentiful.

Of the 186 species that are mentioned in the list as occurring in these beds, 108, or more than one half, are restricted to them, eighty are found in both the upper and lower portion, fifty pass into them from lower beds, and fifty-two pass into beds XII.

The late discovery of natural gas and oil in northern Ohio and Indiana has given us excellent opportunities for comparison. Innumerable wells have been drilled, and of many of them fairly reliable data have been preserved. These are often important and generally most interesting. In this place, however, I shall restrict myself to a few remarks on the northward extension of the 300 feet of shales and limestones which above are described and designated as beds XI.

In tracing the beds northward from Cincinnati it appears that the calcareous material gradually decreases till at Findlay, Ohio,

we find them represented by an apparently uninterrupted series of shales 300 feet thick. These shales, because they are black or brownish and contain *Leptobolus insignis*, have been identified by Prof. Orton with the Utica shale of New York. Though a little anticipatory, I may still be allowed to say here that, judging from the position held by them and from a series of drillings kindly sent me by Prof. Orton, I fully concur with him in thus placing them.

On page 117 of his "preliminary report upon petroleum and inflammable gas," Prof. Orton concludes that in tracing the shales southward from Springfield, to Dayton, then to Middletown (where it is only 100 feet thick) and finally to Hamilton, it rapidly lost in thickness. At the last locality the shale is reported as only 37 feet thick. At this rate of decrease it would, of course, run out before reaching the Ohio river. We must, however, bear in mind that it is only the *black* shale that is decreasing in volume, while, if the 300 feet of this shale at Findlay is not represented in the Ohio valley, the Lower Silurian strata above it must have increased from 460 feet at Findlay to at least 800 feet near Cincinnati.

In my opinion, and I hope to show it in a later installment, this increase is greater than the facts known and relating to the point indicate. For the present it must suffice to say that, if not all at least a large proportion of the strata comprised in beds XI are equivalent to the black or Utica shales underlying Findlay. A study of the tabulated list will show that the Cincinnati exposures of these beds have furnished not only one but at least ten of the species which Walcott and others regard as strictly diagnostic of Utica. When we consider the change in composition, this is as great a proportion of such species as can reasonably be expected.

(*To be continued.*)

GEOLOGY IN OUR PREPARATORY SCHOOLS.

BY W. EDGAR TAYLOR,

Nebraska State Normal School, Peru, Neb.

A loud cry for help is going out from the teaching profession. Information is wanted as to how, what and where, to find means to teach geology. The professional chairs in schools and colleges, no less than the country school houses, are beginning to resound with the inquiry, for guidance, for suggestions, and for direct information as to the ways and means for geological information, and especially for giving geological instruction.— AMERICAN GEOLOGIST.

The Section of Geology of The American Association for the Advancement of Science heeded this loud call in part, at least, by presenting two papers at its last meeting on the subject of geological teaching. But while this need of improvement is felt mostly in the university, the class of schools named can not hope to make much progress in geological teaching till the preparatory schools, including high schools, smaller colleges and normal schools become aroused to the importance of the work. This fact teachers of geology seem to have overlooked entirely. We do not remember to have seen an article on the subject of teaching geology published in any general educational journal, nor have we noticed an article of the kind named, treating the subject as taught in preparatory schools, in any journal or magazine, literary or scientific. Papers on methods and plans of doing geological work and teaching, in larger colleges and universities, are more common of late years, but we repeat, instruction suitable for our preparatory teachers is sadly lacking. This being true, does it seem strange that the methods of teaching this one branch are far behind methods employed in the other sciences? Most teachers of geology in our preparatory schools are not specialists in any of the sciences; most geological literature, owing to its cost, is out of their reach, and geology seldom being mentioned in their general educational readings, their immediate attention is scarcely ever called to the subject. If specialists, their preference more frequently is in some other line, and hence geology is given but little attention. Since the smaller schools have given but little attention to geological work but little time is given to its study, while this

short study is crowded into some out of the way corner of the course. Many of our smaller colleges and normal schools do not give the subject more than ten or twelve weeks, (forty-five minutes per day, five days each week), most all this time being spent in reciting from the text-book.

With these facts before us, it is no wonder, that while almost all schools provide apparatus for teaching biology, physics and chemistry, the material possessed for geological instruction consists mostly of a small collection of fossil curiosities, imperfectly labeled if classified at all. Many schools have well arranged courses in the chemical, physical and biological sciences, with provisions for laboratory work, and why may we not have similar facilities for geological instruction?

With the hope of calling out others the writer submits a brief outline for laboratory and field work in geology, time covering say ten weeks of two recitation periods per day. The outline is only suggestive, and doubtless might be improved in many ways.

We usually begin the study of geology with:

I. Lithology.

1. Mineral determinations.

   a. A written description of at least twenty of the most common minerals to be found in the immediate vicinity. The pupil should be able to determine for himself the following points, viz., form, color, structure, streak, lustre, transparency, cleavage, hardness, fracture, touch and specific gravity. Usually, before the student is asked to make out the above descriptions (unknowns) he should be given a set of typical minerals for careful examination and comparison.

   b. Blowpipe analysis and neat record of at least five minerals. In blowpipe work the student should follow some well defined plan. We would suggest that the minerals be studied in the following order:

   (1) Physical properties.
   (2) Examination in a sealed glass tube or matrass.
   (3) Examination in an open glass tube.
   (4) Examination on charcoal.
   (5) Examination with re-agents.
   (6) Examination on platinum wire.

2. Crystallography.

a. Make with appropriate notes a drawing illustrating each of the six systems of crystallization.

b. Make, of paste-board, clay, plaster of paris, or putty, forms illustrating the six systems.

c. Classify and describe at least six minerals with reference to their crystallization.

3. Collect, classify, label and neatly arrange in a neat box at least twenty-five minerals.

II. Paleontology.

1. Determination and written descriptions of at least ten species of brachiopods. Generally it is best not to aim to classify further than the family name; the object being to give the pupil a clear knowledge of the history and structure of geological species as compared with existing shells. The pupil should be able to determine the characteristics of the shell; viz. locations of the dorsal and ventral valves, forms of internal supports and external markings, beak, hinge-line, cardinal area, deltidium, and internal muscular impressions. In studying external markings observe the length, width, and thickness of the shell, also the sinus, median depression, width and length of the hinge-area, prominence of the beak, number and size of the striations, lines of growth and the comparative measurements of the shell. The forms of the former internal structure in part, may be reproduced by the pupil, who thus gains a more accurate and precise knowledge of the internal markings of the fossil brachiopod. If desired other classes of animals may be substituted for the brachiopod, and studied in a similar manner.

2. Monographs.

The pupil should draw more or less in all geological work, but historical and stratigraphical geology offers special advantages in this direction. Under this heading the pupil may easily be given some idea of the methods of preparing plates and making notes and descriptions. The teacher can not do better than model this work after the plan of standard paleontological reports; making three parts of the descriptions; viz. one plate each, for drawings, explanations and general notes. The drawings may be made with the pencil, but the explanations

and general notes should be written in ink. For a short course in geology we should say that the monograph should consist of not less than four species of at least four drawings each, namely one each of the dorsal and the ventral surfaces, and two sections showing internal structure. For methods of sectionizing fossils, and determining their internal markings we could not do better than refer the reader to Dr. Winchell's Geological Studies.

3. Collect, classify, label and carefully arrange in a neat box or case, at least twenty species of fossils, simply giving family names. Each specimen should have cemented to it a small numbered ticket referring to a catalogue containing notes giving name, locality and geological formation of the fossil as well as the date and by whom labeled and collected. The ticket should be no larger than necessary to contain the number, which should be written in ink and with a pointed pen, and may vary in shape and color in order that the collections of different students may be kept separate.

III. Maps.

One map for each student; standard sizes, say not over 30 x 36 inches. If outline maps can not be procured use heavy paper prepared for architectural drawings or cloth. For a suitable map we usually select a map of North America, United States, or a part of it, or the map of some state. The colors, which should be the standard agreed upon by the International Geological Congress, the United States Geological Survey, or those adopted by custom, may be made in many ways, but we have had better success when using Diamond dye colors. These colors are sold in ten cent packages by all druggists, and one package of each color needed will supply a class of fifty, or more. These colors should be filtered after being dissolved in hot water, and spread on with a tolerably large camel's-hair brush. In coloring the map great care should be taken to get the outlines sharp and not to make the tints too strong. Different maps requiring similar effort may be given to each student. These maps, when accurately drawn and carefully mounted on rollers may be made quite useful in class recitations. Maps on economical geology may be drawn, on a smaller scale, illustrating distribution and production of coal, petroleum,

marble, iron and other useful metals, as well as the precious metals, mining, etc. Many good models for this work may be found in the reports of the tenth census.

IV. Sectionizing.

Under this division we required of our last class the following:

1. Actual section of some bluff showing a *formation*, a *stratum*, and a *lamina*.

2. East and west section of some state. These sections were made in standard colors, on stiff paper, size 12x15 inches, appropriately lettered, with key and proper scale.

3. Section of the Missouri river bluffs south of Peru. This section was required to be made in ink and on stiff drawing paper.

The explanations, plates and notes may be modeled after similar sections in standard geological reports.

The teacher to a certain extent may modify his work to suit the demands and special advantages for certain lines of work.

For example most of the time of the class may be given to certain parts of geology, as mineralogy, paleontology, stratigraphical or geographical geology. The student should be required to keep neat, full and accurate record of all the work done. He may be stimulated much by allowing him to retain, after leaving the class, his records and drawings, including maps and sections, as well as all collections. Ownership is a great stimulus on the part of the student when properly directed by the teacher. At times and under proper conditions, the teacher may even encourage exchanges on the part of the pupils, with collectors living in other localities. However the teacher should see to it that the student does not become a mere collector of curiosities, a class of people found everywhere, but in no sense to be called geologists.

The writer has usually found it best to give about one third of the time for this study to recitations, adapting as far as possible the subject matter of the recitation to the laboratory work.

For example while the class is giving special attention to the brachiopod, and after this family has been pretty well discussed, the teacher may explain other families of mollusca, when the limited time of the class will not permit a more minute study of this class.

As a stimulus toward special readings we have usually required from two to four monographs or essays per term from each student. These essays are written on paper of uniform size say letter paper (10½x8 inches), consisting of four or five pages of reading matter and from one to two drawings illustrating parts of the paper. The subjects assigned vary with the different divisions of geology, but more frequently deal with economical geology. We usually assign each student a separate subject and have a part of the papers read before the class.

EDITORIAL COMMENT.

SOME NEW CONTRIBUTIONS TO THE DISCUSSION OF CORAL FORMATIONS.

Captain W. J. L. Wharton, Hydrogapher to the English Navy, contributes to Nature an account of some coral formations in the China sea—a welcome addition to our knowledge of the facts, doubly welcome in contrast with the unseemly personalities and recriminations growing out of the bitter charges made by the Duke of Argyll against English scientists. Wharton frankly avows his "abandonment of the supposition that subsidence plays a principal part in the production of barrier reefs and atolls," but at the same time is "not satisfied with one part of the explanation offered by Mr. J. Murray." The one element in Murray's theory which does not satisfy Capt. Wharton is the same which Dr. L. E. Hicks in his article, "The Reef Builders," in this number of this journal, regards as the weakest, viz., the competency of sea water to remove, by its solvent action, the great masses of coral which are supposed to have partially filled the deep lagoons of some atolls, and the deep channels within certain barrier reefs.

Referring to the very interesting and important fact ascertained by the Challenger Expedition that pelagic shells falling through great depths are dissolved, Wharton says that the case is very different from the solution of coral rock in lagoons.

The shells fall through a solvent medium, are attacked on all sides, constantly washed clean for a fresh attack, and constantly meeting fresh portions of the liquid. Masses of coral limestone in a lagoon are, on the other hand, attacked only from above, are protected by the debris of their own disintegration, as well as that falling from the surface or swept in by currents, and are long in contact with the same liquid particles.

The readers of Nature will find much to interest and instruct them in the charts given by Capt. Wharton of the Tizard, Macclesfeld, and Prince Consort banks. The central portion of the Tizard bank is from thirty to forty-seven fathoms in depth, with a rim of living coral rising within four to ten fathoms from the surface, some small patches of reef even reaching the surface. The other two banks are similar except that the coral is deeper in the water. Wharton maintains that the progressive development of these banks will result in atolls with deep lagoons, for the production of which neither the subsidence assumed by Darwin nor the solution assumed by Murray, is needed.

His facts will certainly tend to emphasize the opinion expressed at the close of his communication, that a better knowledge of the physical and biological phenomena of coral formations is requisite to settle the theoretical disputes about them.

Mr. John Murray, however, demurs to the proposition that our knowledge is so very limited at present, and re-affirms his faith in the solution theory.

In the same number of Nature (March 1) Prof. G. C. Bourne contributes additional facts derived from the study of living corals at Diego Garcia, and the Great Chagos, Pitt, and Centurian banks. His conclusions are, as he puts it, "nearly identical" with those of Capt. Wharton. He adds however, what seems to us an important suggestion, viz., that currents by their too great violence, or their entire absence, have more to do with the absence of living polyps in lagoons than the supply of food. At Diego Garcia "the most luxuriant coral patches are found at the south end of the lagoon, furthest away from the lagoon outlet." In this case the food supply, which may be assumed to enter by the "lagoon outlet," is manifestly not the most es-

sential condition. But in general the close relation of currents to food supply is so obvious that we cannot regard Prof. Bourne's explanation as independently and universally valid. If taken as not excluding but supplementing the theory that the supply of food is a *sine qua non*, it may command acceptance.

In *Nature*, March 15th, Robert Irvine and James G. Ross give the results of careful study of the solubility of coral rock in sea water. Both conclude that the rate of solution is rapid enough to produce note-worthy results highly favorable to Murray's theory. H. B. Guppy comes forward also with a suggestion to the effect that the *anti-subsidence* theory is not obliged to rely upon solution alone for its validity. It has many other strong points in its favor.

THE PALÆONTOLOGICAL LABORS OF PROF. JOS. F. JAMES.

The destructive tendency exhibited in nearly all of Prof. James' papers, and their extreme boldness, have given them, at any rate so it appears to us, a degree of importance beyond their true merit. They seem also to show little respect for the work of others, some of whom have required many years of pains-taking study to formulate views which he casts aside as worthless. That all men are liable to errors is too apparent to need to be admitted here, yet it is neither just nor possible to set aside an author's views without giving good reasons for doing so. This it seems he has regarded as unnecessary, since in no instance are his views supported by any facts nor evidence beyond his mere assertion. Scientific truths must stand upon more than mere assertions — facts must be cited before they can be regarded as entitled to favorable consideration.

To show that the above criticism is well founded, we will briefly review Prof. James' palæontological papers in the order that they appeared.

In his first paper, which appeared in the Journal of the Cin. Soc. Nat. Hist., vol. vii, 1884, he grapples with one of the most difficult subjects,— the so-called fucoids of the Cincinnati rocks. This group of fossils had been mainly named by Mr. S. A. Miller, though other authorities, among them Prof. James Hal and Mr. C. D. Walcott, also contributed. Prof. James under-

takes to show that all of the fossils in question are referable either to inorganic causes, or to tracks, trails, and impressions of organisms, or were graptolites. Thus, with one stroke, many generic and many more specific names are wiped out. Among these mistreated fossils are several undeniable sponges, their spicular skeletons being known. It is therefore sad to think that such an interesting form as Walcott's *Cyathophycus subsphericus* should have to figure as a mud bubble! Most palæontologists admit that some of the supposed marine plants of palæozoic rocks may be the result of inorganic causes, but there are good reasons to believe that many, if not the majority, will be eventually classified with the spongida.

In the October 1885 number of the same journal we find three small papers from his pen, each acting as a sword to lop off useless names. The first destroys our confidence in a fossil fungus which the venerable Leo. Lesquereux claimed to have discovered in the Coal Measures of Pennsylvania. The second expunges *Ormatichnus* and *Walcottia*, two names that their authors hoped might be useful. The third deals in like manner with *Lepidolites* and *Anomaloides*, two generic names proposed by Mr. Ulrich in 1878 and 1879. Because the former has some outward resemblance to *Ischadites*, Prof. James concludes they must be the same, ignoring the fact that beyond the superficial appearance of the spicular plates there is no resemblance between them, *Ischadites* being built up very much upon the same plan as *Receptaculites*, while *Lepidolites* consists solely of a thin integument of imbricating plates. That these peculiar bodies probably belong to the *Receptaculitidæ*, we freely admit, but they are not by any means the same as *Ischadites*. *Anomaloides* he places as a synonym under *Receptaculites*. Despite frequent examinations of the types of that remarkable fossil we are unable to indicate its natural position, but it is simply ridiculous to identify it with *Receptaculites*. Not a single structural feature is common to them.

His next venture we find in the January 1886 number, when he favors us with a revision of the cephalopoda of the Cincinnati group. Before he undertook this work Cincinnati geologists prided themselves upon having at least thirty-seven species and two varieties in their rocks, but again the useless ones are

thrown out, leaving but twenty-nine. Perhaps to console them he describes the siphuncle of an *Endoceras* upon which the septa have been tightly pressed (a common occurrence in soft shales) as a new species of *Colpoceras*. Such good species as *Orthoceras fosteri* S. A. Miller, *O. cincinnatiense* S. A. M., and *Cyrtoceras conoidale* Wetherby, are consigned to the "limbo of the improbable," while such an evident synonym as *O. hindei* James,[1] stands as a *remarkable semicylindrical shell.* One Niagara and several Trenton species are stated to occur at Cincinnati, while his descriptions are in most cases so vague and meagre that they are, to say the least, no improvement upon what we had before. To begin with, he complains of the fragmentary material upon which some of the species were founded by previous authors, and yet we find in the same number that he describes under the name *Gomphoceras powersi*, a specimen so badly preserved that a generic reference must be purely conjectural. But it is remarkable in having both ends tapering and without septa! At the close of this paper he severely rebukes Prof. Alpheus Hyatt, whom we all supposed knew something of the cephalopoda, for framing a system of classification which is "simply appalling."

Just one year later he publishes a descriptive catalogue of the "Protozoa of the Cincinnati group." In this paper *Microspongia* is placed as a synonym under *Astylospongia*, when he might easily have learned, that these two genera are really very distinct, and belong to different orders. Thin sections (of which he says truly that they are essential to the study of pylæozoic sponges) show conclusively that *Microspongia gregaria* is congeneric with, even very closely related to, the common Niagara fossil *Calamopora fibrosa* Roemer (non Goldfuss), which

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[1] This name beyond question, was given to examples of *O. transversum* S. A. M., which had been partly bedded in soft shale. As is well known all cephalopodous shells occurring in soft shales have lost nearly all of their calcareous material, being generally represented by a delicate brown or black film which weathers away as readily as the shale itself. *O. hindei*, differing in no other respect than in the semicylindrical form from *O. transversum*, was produced by the weathering away of that portion of the shell which had extended up or down into the shale, the form and substance of the other half of the shell being well preserved in the limestone.

Duncan described in 1875 as a new genus of calcareous sponges, under the name of *Hindia sphæroidalis*. The later work of Hinde and particularly that of Dr. Rauff upon this species, goes to show that *Hindia* is a lithistid sponge.

Beatricea he places with the foraminifera and *Stromatopora* and *Stromatocerium* with the spongida, when our best authorities agree that they are closely related genera belonging to the hydroida. *Labechia* he does not recognize, but its species, as well as *Dystactospongia* Miller (a very different and remarkable true sponge) are ranged under *Stromatopora*. With regard to the last genus it is sufficient to say that no true species of it is as yet know from the Cincinnati rocks, nor from any other Lower Silurian horizon. This paper furnishes no evidence that its author had studied any of the recent literature on the sponges, and, as usual, his innovations are retrogressive and detrimental to the progress of palæontological science.

His latest and most important step is to attempt a revision of the monticuliporoid corals of the Cincinnati group. Two parts of this undertaking, in which his father's name is coupled with his own, have appeared in the October 1887 and Jan. 1888, numbers of the Jour. Cin. Soc. Nat. Hist. So far as can be judged from the parts already published, this paper will make rich, almost sensational, reading for some of the authors who have done work in this branch of palæozoology. When their work has been completed the *Geologist* will probably review it at length.

Again the work is highly destructive and retrogressive, since it puts the subject back where it was 12 years ago when Dr. Nicholson first began the preparation of thin sections to show internal characters. These the Messrs. James curtly condemn as a basis for classification, saying that sections are difficult to prepare and unreliable when made. To support this untrue statement they make quotations, all misleading—from Geike, Prestwick, Nicholson and Ulrich. To any one acquainted with the subject this attempt to cast doubt upon the only method known that admits of bringing some harmony and system into the classification of this difficult group of fossils seems insincere. The extreme utility of thin sections in the study of the fossil bryozoa is recognized by all naturalists who are making a

special study of them, and the mere assertion that they are unreliable, can have no effect in delaying the adoption of internal peculiarities as of the first importance in their systematic classification.

He who condemns internal characters as a basis of classification in the bryozoa cannot stop there, but, to be consistent must also carry his condemnation to other classes of animals in whose arrangement they constitute important factors. But we ask, who would for a moment think of overthrowing the admirable system proposed by Zittel for the sponges (which rests entirely upon minute internal characters) for the extremely artificial classification previously in vogue? Or, who would say that because it is generally difficult to determine the interiors of fossil brachiopoda, the arrangment and form of the spirals and other interual features of the shells should not be accorded great classificatory value? Similar questions relating to the value of pallial and muscular impressions, and the hinge peculiarities of the lamellibranchiata, the arrangement of the septa and other features of the rugose corals, (all strictly internal characters) might be asked were they necessary, but, fortunately, scientific inquiry has advanced so far that to call them in question is to insult our highest authorities on those branches of natural history.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

In the Geological Magazine for February the Rev. Norman Glass, long the associate of the late Thos. Davidson in his labors on the British fossil brachiopoda, describes the position of the spirals in these shells. In the spiriferids he says the spirals have their bases facing each other in the center of the shell but their apices point a little upwardly toward the hinder end of the lateral margin. In some Cyrtinas they are directed backward into the rostral cavity as well as upward.

In all the other spiral-bearing brachiopods the spirals are so arranged that a section made transversely through the shell at its greatest circumference would cut the apices and the centers of the bases of the spirals. Thus, in *Athyris* the spirals face each other in the center, and their apices point directly away from one another toward the lateral margins. If they are rotated — both outwardly — about antero-posterior lines passing

through the centers of the bases, the spirals will assume the position that characterizes the genus *Dayia* Dav. Continuing the rotation their position in *Thecospira* Zag., is soon reached, where they point to the bottom of the ventral value. When a half turn has been made and the spirals point toward each other in the center of the shell the position characterizes the genus *Glassia* Dav. After 225 degrees have been passed over and the spirals are directed obliquely into the *dorsal* value, *Zygospira* is indicated, and lastly *Atrypa*, which has the spirals directed to the bottom of the dorsal valve, is represented after a turn of 270 degrees.[1]

The Taconic of Georgia, and the report on the geology of Vermont. By Jules Marcou. (From the memoirs of the Boston Society of Natural History, vol. iv. Read May 4, 1887.) This valuable paper gives some further facts respecting the geology of northwestern Vermont, and sketches the history of the term "Georgia formation." Since the death of Dr. Emmons the burden of the pro-Taconic discussion has been ably maintained by Mr. Marcou, and he welcomes the advent of the new researches and conclusions of Mr. Walcott. "I salute with joy the arrival of new observers, better fitted out and armed than I was, sure that now the truth will not be kept much longer in the background." Mr. Marcou concludes that the term *Lorraine shales* should be used for "Hudson River group," which has become so hopelessly involved. In this he is followed by Mr. S. W. Ford (Am. Jour. Sci. xxix, p. 16). The age of the red sandrock near Swanton he considers still to be somewhat puzzling. He had taken it to be the Potsdam, wholly, but the discovery of the fauna of the Georgia slates in some part of it by Mr. Walcott, he thinks shows it is older than the Potsdam. That is to say, that Mr. Walcott has discovered the middle primordial fauna in it, whereas it seems that Mr. Marcou regards the Potsdam as containing the upper primordial fauna —an assumption which has not yet been established. It is perhaps as likely that the New York Potsdam, when fully examined, will be found to contain the middle as the upper primordial. The "Potsdam fauna"

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[1] The relation here pointed out by Mr. Glass is exceedingly interesting to the palæontologist, and may be thus represented if we begin with the position of the spirals in Athyris as described above.

Athyris	0°	?	135°	Atrypa	270°
Dayia	45°	Glassia	180°	?	315°
Thecospira	90°	Zygospira	225°	Athyris	360°

Where are the genera indicated by the interrogation points, and where are the missing links between the genera already defined? Probably more careful measurement of the angles will bring some of them to light and aid in filling the series.

Similar continuous relations will probably be traced in the structure and position of the loops or calcareous fibers connecting the spirals of which Mr. Glass adds descriptions, as they occur in the leading genera of brachiopods.

as accepted by Messrs. Walcott and Marcou is that of the upper Mississippi valley, and there is, as yet, no evidence to prove that it is found in the Potsdam of New York. On the other hand if that evidence which exists be heeded, the New York Potsdam would be placed in the middle primordial zone. The paper also reviews the report on the geology of Vermont, and the classification of Messrs. E. and C. H. Hitchcock, especially with reference to its date of publication, and that of some of its parts, and brings out fully the unfriendly opposition of the report toward both Emmons and Marcou as well as toward the Taconic system.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Geological survey of New Jersey; Annual report of the state geologist for the year 1887. 45 pp. one map, George H. Cook. New Brunswick.

The gabbros and associated hornblende rocks occurring in the neighborhood of Baltimore, Md.; George Huntington Williams. Bulletin No. 28 of the *U. S. Geological Survey Washington.*

Seventh annual report of the state mineralogist for the year ending October 1, 1887. William Irelan, State Mineralogist, 8 vo., 315 pp. Sacramento, Cal.

2. *Proceedings of scientific societies.*

In the *Transactions of the Field-Naturalist Club.* March 1888. On Utica fossils from Rideau, Ottawa, Ont. *Henry M. Ami.* Notes on geological work during the summer of 1887. *Mr. John Stewart.* Report of the Geological Branch for the season of 1887. *Ottawa.*

Archæology of Ohio. 8 vo., 119 pp. M. C. Read. The Western Reserve Historical Society.

Proceedings and transactions of the Nova Scotian institute of natural science of Halifax, Nova Scotia, 1886—87.

3. *Papers in scientific journals.*

In the March number of the *American Journal of Science.* On the so-called Northford, Maine, Meteorite *F. C. Robinson.* History of the changes in the Mt. Loa craters. *James D. Dana.* The Taconic system of Emmons, and the use of the name Taconic in geologic nomenclature. *C. D. Walcott.* With one plate. On the crystalline form of polianite. *E. S. Dana* and *S. L. Penfield.*

In the February number of the American Naturalist. On meteorites. Dr. Hans Reusch.

In the April number of the American Journal of Science. History of the changes in the Mt. Loa craters. *J. D. Dana.* Notes on certain rare copper minerals from Utah. *W. F. Hillebrand* and *H. S. Washington.* The Taconic System of Emmons and the use of the name Taconic in geologic nomenclature. *C. D. Walcott.* Three formations of the middle

Atlantic slope. *W. J. McGee.* Diorite dike at Forest of Dean, Orange county, N. Y. *J. F. Kemp.*

In the March number of the American Naturalist. Synopsis of Rosenbusch's new scheme for the classification of massive rocks. *W. S. Bayley.* Glacial erosion in Norway and in high latitudes. *J. W. Spencer.*

The Canadian Record of Science for April contains: Preliminary note on new species of sponges from the Quebec group at Little Métis. *Sir J. William Dawson.* Notes on sponges from the Quebec group at Métis, and from the Utica shale. *Geo. Jennings Hinde.* On the classification of the Cambrian rocks in Acadia. *G. F. Matthews.* Notes on fossils from the Utica formation at Point-à-Pic, Murray river. *Henry M. Ami.*

4. Excerpts and individual publications.

Notes and observations on the Kivakiool people of Vancouver island. George M. Dawson. *Trans. Roy. Soc. Can., vol. v, 1887.* Ottawa.

Studies on the stratification of the anthracite measures of Pennsylvania. Henry A. Wasmuth, 4 plates of sections. 18 pp; 50 cents. J. B. Lippincott Co. Philadelphia.

The southern anthracite coal field of Pennsylvania—its enormous disturbances and consequent premature exhaustion. Henry A. Wasmuth. *Jour. Frank. Inst., Feb.*, 1888.

A brief narrative of the Journeys of David Thompson, in Northwestern America. J. B. Tyrrell. *Proc. Can. Inst., Toronto, March, 1888.*

Peridotites of the "Cortlandt series" on the Hudson river near Peekskill, N. Y. George H. Williams. *Amer. Jour. of Science, Jan., 1886.*

On a new petrographical microscope of American manufacture. Geo. H. Williams. *Amer. Jour. of Science. Feb., 1888.*

Note on some remarkable crystals of pyroxene from Orange county, N. Y. George H. Williams. *Amer. Jour. of Science, Oct., 1887.*

The Norites of the Cortlandt series on the Hudson river near Peekskill, N. Y. George H. Williams. *Amer. Jour. of Science, Feb., 1887.*

On the Serpentine (peridotite) occurring in the Onondaga salt-group at Syracuse, N. Y. George H. Williams. *Amer. Jour. of Science., Aug., 1887.*

The chemical structure of the natural silicates. F. W. Clarke. *Amer. Chem. Jour., vol. x, No. 2.*

The genera and species of North American Carboniferous trilobites. Anthony W. Vogdes. Author's edition. *Ann. N. Y. Acad., vol. 4, 1887.*

The geological formation of Long Island, New York; with a description of its old water courses. *John Bryson.*

Precious stones. Extracts from the annual reports of the U. S. Geol. Sur. on *Mineral Resources of the United States* for 1886 and 1887. Also from *Appleton's Physical Geography.* By *George F. Kunz.*

On gold and silver ornaments from mounds of Florida. By *George F. Kunz.* From the *American Antiquarian.* July, 1887.

Gold ornaments from the United States of Columbia. *George F. Kunz. American Antiquarian*, Sept., 1887.

On a large garnet from New York island. By *George F. Kunz.* Read May 30, 1886, before the *New York Acad. of Sciences.*

Meteorites from Glorieta mountain, Santa Fé Co., New Mexico. *George F. Kunz. Ann. N. Y. Acad. Sci.*, vol. iii, 1885.

On the new artificial rubies. By *George F. Kunz. Trans. N. Y. Acad. Sci.*, Oct. 4, 1886.

On two new meteorites from Carroll county, Ky., and Catorze, Mexico. *George F. Kunz. Am. Jour. Sci.*, March, 1887.

The following by *Mr. Kunz* are from the *Am. Jour. Sci.*, Dec., 1887: Waldron Ridge, Tennessee, meteorite; Taney county, Mo., meteorite; Chattooga county, Georgia, meteorite; East Tennessee (?), meteorite; Powder Mill creek, meteorite; Rhodocrosite from Colorado; Hollow quartz from Arizona; A North Carolina diamond; Hydrophane from Colorado, and silver nugget from Mexico.

On the petrographical characters of a dike of diabase in the Boston basin. By *William H. Hobbs.* 12 pp. One plate. Bulletin of the *Mus. of Comp. Zool;* from the Geol. Ser., vol. ii.

The Taconic of Georgia and the report on the geology of Vermont, By *Jules Marcou*; read May 4, 1887. From the memoirs of the *Boston Society of Natural History.*

On the use of the name Taconic. *Jules Marcou.* March, 1887. *Proc. Bos. Soc. Nat. Hist.*, vol. xxiii.

Vol. viii. No 65, of the circulars of Johns Hopkins university contains valuable contributions to the Archæan and Tertiary geology of Maryland, and surrounding regions, by *Prof. George H. Williams, William B. Clark*, and *Wm. H. Hobbs*; Erasmus Haworth has a preliminary notice of the Archæan geology of Missouri, and A. C. Gill a like notice of the eruptives of the island of Fernando Noronha.

The Cosmogony of Genesis, by *Prof. G. F. Wright, Bibliotheca Sacra*, April, 1888.

5. Foreign Publications.

Contributions to the paleontology of Brazil, comprising descriptions of Cretaceous invertebrate fossils, mainly from the provinces of Sergipe, Pernambuco, Para and Bahia. By Charles A. White, with a Portuguese translation by Orville A. Derby. Extracted from volume vii of the *Archivos do Museu Nacional do Rio de Janeiro.* Quarto, pp. 273, 28 plates. *Rio Janeiro.*

On Nepheline rocks in Brazil with special reference to the association of phonolite and foyaite. Orville A. Derby. *Quart. Jour. Geol. Soc., Aug., 1887. London.*

Ueber die Altersfolge der vulkanischen Gesteine und der Ablagerungen des Braunkohlengebirges in Siebengebirge. Mit zwei Tafeln, Von Dr. phil. Gustav Mongold. *Aus dem mineralogischen Institut der Universitat 1888. Kiel.*

Verhandlungen der k. k. zoölogish-botanischen Gesellschaft in Wien. Band xxxvii und xxxviii. 1887.

The Geological Record for 1879. An account of works on geology, mineralogy and palæontology published during the year; with supplements for 1874-1878. W. Whitaker and W. H. Dalton. 418 pp. 1887 *London.*

Annalen des k. k. naturhistorischen Hofmuseums redigirts, von Dr. Franz. Ritter von Hauer. Sieben Tafeln. Band II. Nr. 4. 1887. Band III. Nr. 1. 1888. Wien.

Memorias de la Sociedad Cientifica "Antonio Alzate," Tomo I. Cuaderno num. 8. Febrero de 1888. *Mexico.*

Extrait de l'annuaire geologique, Tome III, 1887. Compt-rendu de publications relatives à la geologie de l'Asie et de l'Amerique par M. Emm. de Margerie 1887. *Paris.*

Memorias de la sociedad cientifica "Antonio alzate." Tome I. Cuaderno num. 9. Marzo de 1888.

CORRESPONDENCE.

Note on the Cascade Anthracite basin, Rocky Mountains. Referring to the analysis of anthracite from the Canadian Anthracite Co's mine published in your issue for March, and the remarks quoted from Mr. Pugh respecting the coal basin in the Bow river valley, it may be of interest to your readers to know that the district in question is described in the annual reports of the geological survey of Canada for 1884, 1885, and 1886. The coal bearing rocks form an elongated basin or trough in the easternmost great longitudinal valley of the Rocky mountains where crossed by the Canadian Pacific railway. This trough has been continuously traced by the writer (as shown on map accompanying the report for 1885) from the Kananaskis river northwestward to lat. 51° 43′ or for about seventy miles. Its northern extension has not yet been fully ascertained as it was not followed in 1884 beyond the edges of the map sheet. The average width of the trough is about two miles, and disregarding minor irregularities, its structure is that of a synclinal completely overturned to the north-eastward so that the beds now dip almost uniformly to the south-westward. The south-western edge of the trough is generally and possibly throughout its length bounded by an extensive fault, which, it has been ascertained by Mr. R. S. McConnell, has at one place (near Caumore) a downthrow to the north-eastward of 10,000 feet. The coal bearing rocks themselves are of lower Cretaceous age and referable to the Kootanie series, with a peculiar and characteristic flora which is described and illustrated by Sir. Wm. Dawson in volume iii of the transaction of the Royal Society of Canada. The ascertained thickness of the Cretaceous rocks here is about 5000 feet, but elsewhere in the mountains the lower part of the Kootanie series, beneath the principal coal-bearing horizon, is known to have a volume of about 7000 feet. The Cretaceous infold here

specially referred to has been named the Cascade Anthracite basin and is almost continuously bordered by high mountains composed of Devonian and Carboniferous limestones (Intermediate and Bauff limestones of Mr. McConnell's report). In other long Cretaceous basins which occur in the mountains for some distance southward, good coking bituminous coals are found, but in the Cascade basin only has the alteration been carried so far as to produce anthracite.

A partial analysis of the Cascade anthracite, which closely agrees with that of Prof. Dodge, will be found in *Notes on coals and lignites of the Canadian Northwest, Montreal*, 1884. Several additional analyses appear in the reports of the Geological Survey for 1882-84 and 1885. These are by Mr. G. C. Hoffmann who has also determined the evaporative power as 7852 calorics or 14.62 lbs. of water at 100° C. evaporated by one pound of coal. This evaporative power was determined from a specimen somewhat inferior in quality to the coal now mined. No ultimate analysis of the coal has, so far as I know, yet been made.

In consequence probably of strains subsequent in date to the complete mineralization of the coal, portions of the seams have been found in a shattered and slickensided state, but the prospects for profitable mining on a large scale appear to be in general very favorable.

George M. Dawson.

Nomenclature of some Cincinnati group fossils. Letter from Prof. Joseph F. James. In the March number of the "*American Geologist*" the list of fossils beginning on page 183 contains some errors, probably errors of oversight, but which should be corrected. Reference in particular is made to numbers 94, 143, 149, 153, 164, 165, 303, though there may be others. All of these species are credited to Nicholson, whereas they should have been given to Mr. U. P. James. Some of them were, it is true, *described* by Dr. Nicholson, but were by him duly credited to Mr. James, who had given them the names under which they are now known. It is a little strange that these species should be in this predicament, while others named and described under similar conditions are properly credited. As examples of these there are numbers 216, 223, 241, 243, 255, &c. Mr. Ulrich will, it is presumed, when attention is called to the error in his paper, correct it, so that future investigators may not fall into errors concerning the species that have been mentioned.

Joseph F. James, M. S.

Miami University, Oxford, O., March 17, 1888.

Reply of Mr. Ulrich. The species referred to in the above communication by numbers 94, 143, 149, 153, 164, 165 and 303 are respectively, *Stomatopora frondosa*, *Aspidopora calycula*, *Batostomella gracilis*, *Bythopora delicatula*, *Leptotrypa clavacoidea*, *L. discoidea* and *Pleurotomaria ohioensis*. With regard to the last I will at once concede that the species should be credited to Mr. U. P. James and not to Hall as it appears in the list. This is purely a clerical error. Prof. James commits another when he states that we have credited the name to Nicholson. The authorities

given in the other cases are properly cited and in strict conformity with commonly accepted rules of nomenclature. This will appear from the following facts: The first, third and sixth of these specific names appear in Mr. U. P. James' *Catalague of the Fossils of the Cincinnati group*, published in 1871. Being unaccompanied by either figures or description, it is evident that the species must be considered as *unpublished*. The rules are very clear upon this point—"A species announced in a publication but without any description cannot be considered as published."[1] In vol. ii of the Ohio Pal., Dr. Nicholson both describes and illustrates these species, but credits Mr. James with the names. Now, this being the first proper publication of the species their date is necessarily the same as that of the volume, and, as they are there described by Nicholson and *not* by James, they are *established and stand upon the authority of the former*, despite the fact that injudicious sentiment on the part of Dr. Nicholson led him to credit them to Mr. James. Had the former quoted the latter's descriptions of the species the cases would have been different; —but he did not. Furthermore, we have no absolute certainty that the species so named by Dr. Nicholson are identical with those to which Mr. James applied the name in 1871, since the latter has not yet published descriptions of his species.

In nomenclature, which can only be made uniform by strict adherence to established principles, sentiment of the kind mentioned should stand aside, since it almost invariably breeds confusion. Viewing the matter from another point we can readily imagine cases where an injustice may be perpetrated upon the author of a manuscript name. No responsibility rests with him till he has perfected his claim to the name by giving it adequate publication. Before he has done so, however, some other author may apply his name to a form perhaps quite distinct from the one he intended to give it to. In this case the name would have to stand upon the authority of the second author for the species to which he applied it, while the first claimant would not only be forced to select a new name for his species, but would stand credited with another, the very existence of which he may not have suspected before. Again the author of a manuscript name might upon subsequent investigation learn that the form he intended to describe under it was really not sufficiently distinct from previously published species to justify separation. In the meantime, another author, not so well informed, may have published a description of the form and given the original author as authority for the name.

We might go on at length but the point seems so obvious that what has been said already appears superfluous.

As regards the fourth name, *B. delicatula*, the complainant must be in error. We cannot find that Mr. James ever described this species or even proposed the name.

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[1] Report to A. A. A. S. on Nomenclature in Zoölogy and Botany, p. 35 (Dall).

The second and fifth names (*L. calycula* and *clavacoidea*) may apply to species which Mr. James has described. On this point, however, we are in doubt, since his descriptions are unaccompanied by figures and so brief and vague that it is very difficult, if not impossible, to identify his species. Mr. James has described a large number of bryozoa in this manner, and not only we but others have experienced the same difficulty in attempting their identification. Some of these species (the two in question among the number) have been very fully described and illustrated by Dr. Nicholson,[1] and so, while we do not yet know what Mr. James intended to name, we *do* know what species Dr. Nicholson had before him when he drew up his descriptions. Hence it is Dr. Nicholson's species *calycula* and *clavacoidea* that are referred to in the list and not Mr. James'.

The other species which are said to have been named and described under similar conditions, but properly referred in the list, are: ***Orthis bellula, O. multisecta, Zygospira cincinnatiensis, Z. kentuckyensis*** and ***Streptorhynchus nutans.*** Of these the first three and the last should be credited to Mr. Meek for the same reasons as those mentioned in treating of ***Stomatopora frondosa, Batostomella gracilis*** and ***Leptotrypa discoidea.*** Mr. James neither described nor illustrated the species, while Mr. Meek did both.

In preparing the list, brachiopoda and other classes of fossils, excepting the bryozoa, were simply copied from one of the published catalogues of the Cincinnati group fossils. In these the references stand as given by Meek. As the points here at issue were not at that time in our mind the change of authorities was overlooked. The bryozoa, however, were taken from our manuscript catalogue, in which the changes had been made some time ago.

Z. kentuckyensis (a very large var. of *modesta*) is credited to Mr. James because it appears to be new and is one of the few forms described by him that we can identify.[2] There is therefore nothing remarkable in referring to him as authority. E. O. Ulrich.

Newport, Ky., April 13, 1888.

PERSONAL AND SCIENTIFIC NEWS.

Prof. J. S. Newberry, of the School of Mines, Columbia College, N. Y., receives the Murchison medal from the Geological Society of London—a worthy compliment to one of the worthiest of American geologists.

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[1] The Genus Monticulipora, pp. 165 and 182; 1881.

[2] The question, does Mr. James' "The Palæontologist" fulfill the requirements of a proper publication? is not at issue here. If it were, I should be seriously inclined to answer in the negative.

FROM THE REPORT OF ROBERT T. DAY, chief of the division of mining statistics, U. S. geological survey, we learn that the total value of mineral products in this country for 1886 was $465,327,888. During the three years 1882, 3 and 4 the production steadily diminished. In 1885 it increased slightly, and in 1886 it exceeded the very large product of 1882 by $9,162,-399. The fluctuation is chiefly in the metallic minerals, especially iron, the non-metallic minerals, such as coal, being nearly constant. The production of the precious metals, gold and silver, is much more constant than that of iron, but the value of iron ($95,000,000 in 1886) is greater than that of gold and silver combined ($86,000,000).

Coal exhibits an output still more valuable than iron, viz., $154,000,000, about equally divided between bituminous and anthracite. Thus we find the non-metallic minerals decidedly in the lead. One of them is first of all in aggregate value; their production is more constant; and the total value of the non-metallic minerals exceeds that of the metallic by $34,000,000 notwithstanding the incompleteness of the statistics. Under "mineral products unspecified" are lumped together a great number of common products of the earth, such as clay and sand, with a total estimated value of $6,000,000, which is much too low. If complete statistics of these could be obtained the excess in value of the non-metallic minerals would be largely increased.

The first ten minerals in the order of annual value in round millions are:

1 Coal	154 millions	6 Petroleum	20 millions
2 Iron	95 "	7 Building stone	19 "
3 Silver	51 "	8 Copper	16 "
4 Gold	35 "	9 Lead	12 "
5 Lime	21 "	10 Natural gas	9 "

DR. REUSCH ON METEORITES—In a lecture delivered at the University of Christiana, Norway, Dr. Hans Reusch gives a learned and interesting dissertation on meteorites. In Norway they are popularly known as "*thorelo*", *i. e.*, the *wads of Thor*. One is apt to think that if the wadding of the thunder-god is so formidable, his solid shot must be portentous indeed.

Under the head of "phenomena accompanying the fall of meteorites," Dr. Reusch describes the descent of the Tysnæs meteorite which came down "like a shot bird," about a minute after a loud report had been heard in the heavens. No fiery display was witnessed by observers at the spot, apparently because it was over their heads; but distant observers saw the usual phenomenon of a fire-ball rushing rapidly through the air and exploding.

The most significant observation in the lecture is that the internal structure of the Tysnæs meteorite, which belongs to the stony group having little iron, indicates that it has been broken

o pieces and the fragments reünited at least twice before it entered the earth's atmosphere. It is in fact a conglomerate in which the component pebbles are themselves conglomeritic.

In searching for a cause of this singular structure Dr. Reusch cites the probable conclusion, deduced from the periodicity of meteoric showers that these bodies travel through the interstellar spaces in flocks, like the component particles of a comet, and with similarly elongated orbits. In perihelion they are rent in fragments and partly melted by the intense heat. The fragments may be rounded by mutual impact and attrition, then recemented by the molten matter. The Staelldall meteorite shows rounded fragments in a magma of brownish glass.

THE NEW MAP OF EUROPE. The list of subscribers to this map given on page 252 should have included the University of California which was inadvertently omitted. Since then the following subscriptions have been made, leaving only thirteen copies now available, viz.; J. B. Hastings, Ketchum, Idaho; Geological survey of Minnesota, Minneapolis; R. D. Lacoe, Pittston, Pa.; University of Wisconsin, Madison, Wis.; Vassar College, Poughkeepsie, New York; Mt. Holyoke Seminary, South Hadley, Mass.; Colby University, Waterville, Me.

LATER CRETACEOUS IN IOWA. Mr. A. G. Wilson, of Hopkinton, Iowa, states in correspondence that at about five miles north of Mt. Vernon, in Linn county, Iowa, a fossil, supposed to be *Belemnitella mucronata* was found about forty feet below the surface, in the drift, and its origin could not have been much further west. In vol. i of the final report of the Minnesota geological survey, page 599, Mr. Warren Upham states that the shales of the Fort Pierre and Fox Hills groups are indicated by fossils found *in situ* in numerous instances in Yellow Medicine and Lyon counties; also on p. 584-85 that *Baculites* and *Inoceramus* are frequently found in the drift in Brown county. Mr. J. H. Kloos states (*Am. Jour. Sci.* (3), iii, 24), that *Baculites* has been found in Nobles county, and infers that the latest members of the Cretaceous exist in Minnesota.

Prof. E. Haworth also writes that the fossil plant mentioned by Dr. C. A. White, in his article on p. 227, indicating the Dakota group of the Cretaceous, was found at Oskaloosa, Iowa, abont eighty miles nearly due south from the locality of the invertebrate fossils, and in a boulder lying on the surface.

Probably the most eastern point in the Northwest at which the Cretaceous has been identified, is in the northern part of Goodhue county Minnesota, where shales and sandstones of the Dakota group are opened up for pottery-ware. Dr. Lesquereux has fully identified the plant remains and refers them to the earlier Cretaceous. This locality will be described in the forth-coming vol. ii, of the final report of the Minnesota survey.

Prof. E. Hull reviews in the Geological Magazine for March, the various opinions that have been put forward regarding the effect of continental lands in raising by attraction the level of adjacent oceans. Suess and Fischer, basing their calculations on Airy's observations of the variation in the number of beats of the seconds pendulum, on oceanic islands and at coast stations, made the difference of oceanic level between California and the Sandwich islands equal to 4520 feet—a result scarcely credible.

The author with the assistance of Prof. G. C. Stokes has tried to calculate the effect of the attraction of the continental masses on the oceanic waters, and states the following results as the elevation above geodetic level:

For the coast of Mexico	780 feet.
" " Bolivia	2,159 "
" " Chili	1,582 "

In the Quarterly Journal of the London Geological Society for February Dr. Lyddeker discusses at length the various genera of Sauropoda founded on separate bones, and gives his reason for uniting several of them in the single genus *Ornithopsis*, and concludes, after a few remarks on the Theropoda, with a note pointing out the extremely unsatisfactory condition of our knowledge of these reptiles, and reflects on the practice of setting up new genera for every new bone discovered, or "even a fragment of a single bone." "It is the easiest thing in the world to apply a new name to any specimen that turns up, but when we find one genus founded on a humerus, another on a cervical vertebra, a third on a caudal vertebra, and a fourth on the cast of a sacrum, the evil results of such a system are self-apparent." "It would be advantageous if we were beginning *de novo* to take one particular part of the skeleton and say that on the evidence of that part alone generic terms should be made, but such a rule would be of little use now." Still it is a necessary evil, incident to our imperfect knowledge, that the femur of an animal bears one name and the humerus another, while in some cases possibly several bones from the same skeleton are figuring before the palæontologist as real beings. In days to come it will be picturesque to see the whole skeleton restored, each bone bearing a separate specific and possibly generic designation.

On nearly the same lines Prof. H. G. Seeley describes from a part of a vertebra a species which he has named *Thecospondylus daviesi* and on this small foundation attempts to build up the vertebra and then the animal with "an elongated head and long slender jaws and neck" "so that the measurement from the tip of the snout to the extremity of the tail may have been under ten feet; of active habits, with long limbs and specialized extremities."

THE

AMERICAN GEOLOGIST

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SOME AMERICAN NORYTES AND GABBROS.

Geological notes from the laboratory of Denison University.

I.

BY C. L. HERRICK, E. S. CLARKE, AND J. L. DEMING.

The material for this paper was gathered in various parts of the United States and Canada, the species selected for description being chosen for their supposed bearing on the genesis of this family. The norytes and gabbros constitute a very interesting group which may be regarded as forming a link between the diabases and basalts on one hand and the diorytes and other paragenous eruptives on the other.

The view held by the senior writer that older eruptives are to be classed in one or other of two groups, depending on the method of origin, has already been foreshadowed in a paper in the second volume of the bulletins of Denison University. All the older eruptives which are apparently independent, so far as composition is concerned, of the influence of the interpenetrated rocks are termed *Autogenous eruptives*. Illustrations are afforded by ordinary diabases and basic gabbros and norytes. The remainder of what are commonly known as basic eruptives, which show in their composition the obvious effect of the country rock, are termed *paragenous eruptives*. And, however much the texture may vary in each of these, it is claimed that they constitute rather sharply and naturally distinguished assemblages. The paragenous species may assimilate closely to the wall rock or may resemble very nearly the parent autogenous species. The diorytes are of this nature, at least in

most cases. Such rocks would be expected to resemble ordinary metamorphic sedimentaries in the inclusions.

Garnet and the various metamorphic accessories then would be quite at home in the paragenous but foreign to the autogenous eruptives. Illustrations of these distinctions can be found in any highly metamorphic region, and while it may be easy to find instances where diorytes form apparently autogenous dykes, yet it is claimed that they may generally be traced to some relation with dykes of the first order and owe their origin to secondary fusion and perhaps also to a commingling of true igneous matter with such products of fusion as can be traced to the adjacent wall-rock. If this view be correct, the group at present under consideration may be regarded as standing on the boundary between the two classes. The resemblance between certain norytes, especially the olivine-bearing variety and diabase, is so close as to baffle discrimination in the field. In like manner we shall be able to establish a close connection between gabbro and diabase in the Duluth locality. The present purpose is merely to call attention to three distinct phases of this group with some remarks upon the relations sustained by them to adjacent rocks.

1. (1146) *Olivine noryte*, near Marshall, N. C. (sp. gr. 2.99.) This rock occurs about six miles northeast of Marshall in the form of a dyke of variable width, penetrating the gneisses and micaceous schists, and forming the axis of a considerable area of metamorphism. The walls of the dyke are formed, in many places at least, by a zone of dioryte to be described further on. To the presence of this, or a related dyke, is probably to be ascribed the segregation of ore in the iron mines in this locality. The typical phase of this noryte, as seen in the outcrops at Bull creek, is a very coarsely crystalline purplish-black rock with well-defined black crystals of an orthorhombic mineral. The feldspar is in elongated narrow twins, while irregular, greenish, glassy masses of olivine can be distinguished here and there. The feldspar is very dark, evidently from a suffusion of the coloring matter of the bronzite. The only other ingredient which can be distinguished in the hand sample is magnetite, to which the high specific gravity may be largely attributed.

The relative proportion by bulk of the ingredients as estimated from measurements of the microscopic section is as follows: olivine, 17.36 per cent., bronzite, 20.87 per cent., magnetite, 6 per cent., biotite, 2.8 per cent., labradorite, 47 per cent., chlorite, 2.4 per cent., apatite, etc., 3.57 per cent. These of course are empirical and derived from few measurements. The section affords beautiful twins of plagioclase with brilliant polarization and a tendency to coalesce into aggregates with the axes at right angles. The angles noted on either side the twinning plane were 14°—16°; 12°—14°; 12°—15°; 15°—16°; indicating labradorite. On pulverizing the rock and separating by use of sonstadts solution, the feldspar gave a specific gravity of 2.77, the slightly excessive weight being apparently due to the suffusing coloring mattter so characteristic of the feldspars of this rock. The pyroxene is very dark brown and affords the well developed cleavage lines parallel to 1. In cross section the peculiar cleavage parrallel to $i-\breve{i}$ is seen as very fine, closely arranged lines with inclusions of a black mineral. To this cleavage the extinction is perpendicular, showing the species to be orthorhombic, with the characters of bronzite. It is not rare to find twins or aggregated crystals with $i-\breve{i}$ as the twinning plane. A thin lamina may be interpolated in an otherwise perfect crystal with no obvious rotation of the interpenetrating member. The bronzite is cut by both feldspar and olivine. This latter ingredient is in rather large corroded crystals, evidently at one time of perfect form I, $i-\breve{i}$, $i-\bar{i}$, *O*, and was the first of the essential minerals to form. Its sections are everywhere broken by irregular fracture lines which are followed by inroads of the superficial decomposition, and the outer portion is frequently altered to a reddish aggregate, but is also usually enclosed by a considerable zone of bright green chlorite with vivid blue polarization colors. The magnetite is found both in regular crystals and in corroded irregular masses. The magnetite is generally bordered by a zone of reddish matter stained with hæmatite and frequently is accompanied by scales of biotite. The chief remaining accessory is apatite in moderate abundance. The rock is thus fully described because of the doubt cast upon the specific integrity of noryte by many writers,

and Rosenbusch's statement that it has been found only in the northern regions of America.

2. The adjacent paragenous rocks are hardly less interesting than the noryte. They consist of accessory dykes and flows of *dark porphyritic dioryte*, very dense and hard. The section displays much segregated biotite and hornblende with iron oxides. The feldspars are oligoclase and orthoclase with prevailing Carlsbad and occasionally Baveno twins. The feldspars and quartz are full of liquid and other inclusions. The most important solid inclusions are garnets in large, richly-colored specimens as well as in very small perfect isotropous crystals. Apatite is likewise abundant. The structure of the diorytes can be easily explained by reference to the schists which make the country rock at this place. These schists abound in corundum minerals and the silicates, and there are local masses of rutile, but a chemical examination of the magnetite of our noryte failed to reveal any titanium. The magnetite in the diorytes is in the form of aggregates occupying elongated or dendritic cavities among the hornblende and mica. Hæmatite is abundant as an alteration product.

3. *The Duluth gabbros.* This is a peculiarly interesting series and has already been the topic of considerable discussion. It is probable that the vexed question of the relations of the rocks associated at Duluth could be solved by a sufficiently extended study in the field and the laboratory. Meanwhile, a few suggestions are offered.

The rock which may, perhaps, be regarded as typical of the primary overflow, is seen at the north east of the city, where it is now extensively quarried. It is an intensely black rock with a specific gravity of 2.77, containing long bladed feldspar and regular but corroded augite. The deep color is largely due to the suffusion of iron oxide, the magnetite being badly corroded and affording hæmatite by alteration. Technically this species is diabase, but it is closely related with the gabbros and possesses certain peculiarities which may explain the relation. The structure of the feldspar is peculiarly instructive upon this point. Many of the plagioclases are zonary, and, though a hasty examination might read them oligoclase, greater care will generally show that the central zone is of a higher basidity than the outer;

indeed, it not unfrequently happens that the central portion retains its original character with multiple twins and a ratio of c to c agreeing with labradorite (in one case 25° —26°)while the outer zone is monoclinic, with characters of orthoclase. These zones are commonly separated by an irregular band of alteration, which is granular, greenish-white and isotropous. All stages between crystals in which the basidity of the zones is nearly the same and those described can be traced. The only other characteristic of moment is the enormous development of apatite, (see fig. 8). (Irving remarks upon its absence in this series). The most obvious explanation of these structural peculiarities is that the rock was primarily a true diabase with labradorite as its feldspar, but that the process of decomposition has been inaugurated by a leeching out of the calcium and sodium and its replacement about the periphery by potassium. The source of the potassium might be sought in meteoric water from kaolinizing adjacent acid rocks. But we shall have occasion below to assume for some of the adjacent orthoclase gabbro a mixture of acid and basic rock on a large scale in order to explain the origin of the orthoclase.

The *ordinary gabbro* of Duluth is already known from many descriptions. It is found exposed along the principal street and is used extensively for monuments, etc. The labradorite is in beautiful large crystals, the pyroxene is green diallage in small amount, magnetite and apatite making up the section. Its specific gravity is 2.9. To the westward rise parallel ridges extending north and south and these are composed of different phases of the same series. Upon the first low range appears the red fine-grained variety next to be described, which abuts upon the gabbro by a tortuous but rather distinct line of contact. This has been called *orthoclase gabbro* but its relation to the typical species has not been explained. The hand sample resembles a close-grained hornblendic granite or syenite, but obviously differs in the slender rod-like form of its feldspar. The section shows all the ingredients to be altered. The alteration is of the character which can best be explained as the result of intense heat, and resembles that induced in a granite which has been broken up and its fragments encased in a basic eruptive. There is a well-defined pseudo-porphyritic structure.

The magma consists of reddish or whitish amorphous material masking feldspar crystals of the first order. The diallage is equally altered but retains its green color and optical properties. The greater number of porphyritic crystals are less obviously altered and preserve their outlines. Most of them are oligoclase or orthoclase. The primary feldspar is often obviously of a higher basidity. Secondary quartz is also present. The most natural way to account for the peculiarities of this rock, which occurs also on the ranges further west, would be to regard it as paragenous and formed below the surface by interaction of the gabbro or diabase flows on an acid country rock, in the process of which the crystallizing autogenous material became more or less mingled with secondary fused matter from the walls. This process would then be quite analogous to that involved in the formation of the porphyritic felsytes and paragenous diorytes of the north shore and elsewhere. The fact that the feldspars of the first order are more basic favors this view. Microscopic examination of the contact between the true gabbro and the red orthoclase-bearing variety seems to substantiate this theory also. The plagioclase on the gabbro side becomes less basic from diffusion from the contact, while those of the other side react as monoclinic and are iron-stained and greatly altered, yet even these often exhibit traces of previously existing multiple twins. We are driven to the conclusion that the red rocks are the product of mingled autogenous gabbro with secondary acid material from the walls, and the interaction of the two under pressure and long continued high temperature. The presence of potassium and sodium salts would explain the development of secondary quartz and the paragenesis of the feldspars.

We have space to mention but one other member of this group. The *garnetiferous gabbro* from Granite Falls, Minn. This is selected as still further illustrating the paragenous tendency of gabbro. This is typical gabbro in its essentials, the greater part of the section consisting of a rather low-angled labradorite and abundant diallage of an intense green color. But the specimen is remarkable for large grouped garnets and free quartz, together with a very small amount of hornblende as alteration product of the diallage. The quartz and garnet

are full of inclusions and the latter is nearly always associated with magnetite in corroded grains. The plagioclase and diallage are so fresh that it is believed that these accessories can not be the product of internal decomposition. The almost complete limitation of garnet to metamorphics is additional reason for the inference. The present writers, unfortunately, have had no opportunity to personally examine this locality, hence can bring to bear no topographical evidence. An examination of a number of so-called quartz-diabases and garnetiferous diabases has shown them all to be diorytes, or easily explained as a mechanical mixture due to the explosive dis-memberment of a granite when embraced in a dyke-mass. Instances of this sort are very well seen in Michipicoten bay where a diabase dyke not infrequently contains in itself scattered fragments of the adjacent granite, the fragments being of all sizes and exhibiting in a beautiful way the contact phenomena where heat out of the presence of vapor is the sole agent. A specimen now before us might easily be called a quartziferous diabase had we not traced its relations as indicated beyond peradventure. The naming of such a chapter of accidents tends we think to confuse and retard our progress toward a classification which shall be natural in the sense of expressing the relationships and development of the rocks.[1]

Since writing the above the valuable paper by M. E. Wadsworth entitled *Preliminary Description of the Peridotytes, Gab-*

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[1] Irving (Copper-bearing rocks of lake Superior) states that "the distinction between diallage and augite is a valueless one, since not only are both often found in the same section but every gradation is found in rocks of this class from augite to diallage."

To this it may be replied that while it is doubtless true that such transitions occur, that fact does not obliterate the value of discriminations based on two minerals so distinct when typical, or of varieties of rock so unlike in appearance and occurrence as diabase and gabbro. It might be urged with equal truth, because augite and hornblende pass into each other by alteration and both occur in the same rock, that diabases and diorytes should not be distinguished. It is customary to divide the rocks of the lake Superior region into original and detrital. The term "original" seems misleading, for it is certain that a large part of the basic and acid eruptives are paragenous in the sense defined above and are quite distinct from the autogenous members, which alone deserve to be called original, though both are undoubtedly eruptive in origin.

bros, Diabases and Andesytes of Minnesota, has come into our hands. Inasmuch as this work touches substantially the same ground as that covered by our notes a few words may be necessary in further explanation. We differ most radically in the theory proposed to explain the origin of diorytes. Believing as we do that Dr. Wadsworth has laid lithological students under great obligation by calling attention to the genetic relations of various species and attempting to base a classification on the actual relationships of the species, we dissent from many of his conclusions and think his own work abundantly demonstrates that we can ill afford at present, to neglect for a nomenclature which can only express individual interpretations of endogene modifications, the accurate and highly useful mineralogical system of Rosenbusch, which seemed at one time likely to give us a uniform cosmopolitan terminology.

We believe field-work will bear us out in suggesting that the reaction between diabases and acid country rock is alone competent to explain the origin of most diorytes. The decomposition of diabases in no case so far reported produces a true dioryte. Further, it seems probable that the reaction was cotemporaneous rather than subsequent. This radical difference is really less important as affecting the classification of Wadsworth than it would at first seem. We would write, for example.

Diabase Hornblendic schist.	dioryte,
Noryte Mica schist.	mica dioryte (garnetiferous),
Diabase Chloritic quartz schist.	mica dioryte (calciferous),

It seems strange that in studying the series of gabbros from Minnesota Dr. Wadsworth should have failed to notice the paragenesis of plagioclase. He mentions, indeed, its "replacement by ferric oxide, viridite, micaceous minerals, magnetite, *orthoclase*, quartz, epidote, etc.," but seems to consider it of no greater importance than a stage in decomposition. A careful study of contact phenomena between quartz-porphyry and diabase porphyryte and olivine diabase at Michipicoten island, confirms the belief that the change from anorthite or labradorite to orthoclase is a constant symptom of interaction of the kind indicated above.

DESCRIPTION OF PLATE.

Figs. 1-4. Zonary feldspars from black diabase north east of Duluth. Outer zone orthoclase or oligoclase, inner zone labradorite, with amorphous zone between.

Fig. 5. Section from noryte near Marshall, N. C.; *b*, bronzite showing both cleavage systems. The fine lines are parallel i-i, in which zone lies the interpenetrating lamella; *o*, olivine; *f*, labradorite feldspar.

Fig. 6. Portion of the same section showing occurrence of biotite (*m*) about the magnetite; *o*, olivine; *a*, apatite; *ch*, chlorite; *p*, plagioclase.

Fig. 7. Portion of same section illustrating the occurrence of the magnetite; *m*, biotite mica; *p*, plagioclase. Granular decomposition product filling interstices.

Fig. 8. Portion of section from diabase of Duluth; *a*, augite; *ap*, apatite; *f*, feldspar.

Fig. 9. Crystals of garnet (?) from dioryte adjacent to noryte of figs. 5-7.

Fig. 10. Feldspar paragenesis in so-called orthoclase-gabbro of Duluth; *d*, diallage.

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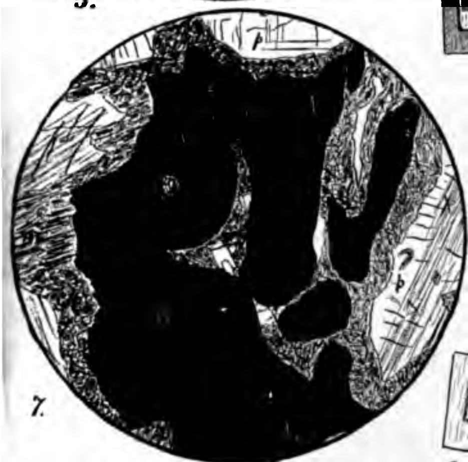

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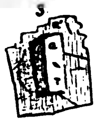

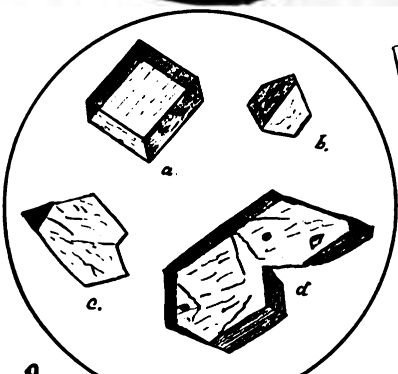

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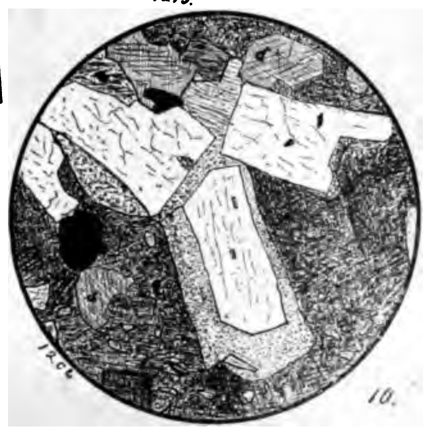

10.

THE TACONIC QUESTION.

BY ALEXANDER WINCHELL.

CONTENTS.

The following concise statements of the elements of the question concerning the Taconic, may prove helpful to the young student who lacks time or opportunity for consultation of the original documents. The writer undertook the investigation with complete freedom from bias, save that his patriotism was predetermined to claim for American geology all that belongs to it. The research is not continued into the later history of Dr. Emmons' work in this field, because the validity of the name must rest on facts connected with the period of its first proposal.

I. Original proposals of the founder of the Taconic system.

1. *Date of first definition.* The term Taconic system was first employed by Dr. Ebenezer Emmons, in the final report on the geology of the second district of New York, the preface to which is dated January 1, 1842.[1]

The conception of the system existed in his mind, as he tells us, long before. "When, in 1836, I determined that in New York, the Potsdam sandstone was the base of the Silurian system, it seemed that we had at that time, the base of the sediments; but when two years subsequently I had observed the same base resting on sediments still older—as those along the eastern side of Champlain and elsewhere—it became evident that there was still a series older than the Silurian. The proof of this has been accumulating ever since; and the Taconic system is found to rest upon primary rocks without an exception; and it has now been observed through the whole length of the states, from northeast to southwest. It is worthy of note, that through this whole extent, the base is continuous."[2]

2. *Stratigraphical position.* "A group or system of rocks which belong evidently to a position between the primary of the Atlantic ranges of mountains and the New York system." That is, between the crystalline schists and the Potsdam sandstone. This was a first formative conception of the stratigraphic limits of the system. It would be anticipated that the precise limits would be fixed by subsequent observations. For instance, the rocks naturally referable to the system might not always rest on the crystalline schists; and on the other hand, the upper limit might not finally be fixed at the base of the Potsdam sandstone.

3. *Geographic position and distribution.* The typical rocks "lie along both sides of the Taconic range of mountains, whose direction is nearly north and south, or for a great distance parallel with the boundary line between the states of New York, Connecticut, Massachusetts and Vermont. The counties [in

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[1] Constituting chapters VII. VIII, and IX.

[2] American Geology, pt. II., The Taconic System. [Albany, 1855,] pp. 5 and 6.

New York] through which the Taconic rocks pass are Westchester, Columbia, Rensselaer and Washington; and, after passing out of the state, they are found stretching through the whole length of Vermont, and into Canada, as far north as Quebec. It is however, in Massachusetts, in the county of Berkshire, that we find the most satisfactory exhibition of the rocks. They form a belt whose width is not far from fifteen miles, along the whole western border, and which extends clearly to the western base of the Taconic range. The greatest breadth therefore, as will be seen, by an inspection of any map of this section of country, is wider upon the eastern than upon the western side of this range. In Vermont, they range along the upper members of the Champlain group, and thus become connected with the Second District." [p. 136].

The "Black slate" "extends as far as St. Albans in Vermont." The "Taconic slate, with its subordinate beds, occupies almost the whole of Columbia, Rensselaer and Washington counties." The Sparry limestone passes through Ancram, Hillsdale, New Lebanon, Canaan, Berlin, Petersburgh, Hoosic, White Creek, the west part of Arlington, [Vt], and onwards in the same range north, through the eastern townships of Canada East."[1] The magnesian slate forms the highest mountains in the Taconic range, which "extends along the western border of Massachusetts and through Vermont."

In 1846, the occurrence of Taconic rocks was announced in Rhode Island, Maine and Michigan."[2]

In 1855, Dr. Emmons announced that the Taconic system of rocks had "been observed through the whole length of the states from northeast to southwest * * * The most northeasterly point at which I have observed this system is at the Fox islands, off the coast of Maine, but I have good reason to suspect its existence in Newfoundland. If so, it ranks among the most persistent geological formations of the country."[3]

It is not necessary to follow Dr. Emmons' later identification of the Taconic in North Carolina and other regions.[4]

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[1] Agricultural Rep., 74.

[2] Report on Agriculture, pp. 90—101.

[3] American Geology, pt. II, pp. 5 and 6.

[4] Geological Report of the Midland counties of North Carolina, Raleigh, 1856, 8vo.

4. *Constitution.* In the first enunciation of the system, Dr. Emmons was not fully persuaded of the order of superposition of the strata embraced in the Taconic belt. Leaving that determination to the future, he described them in geographical order from the west. As the general dip was easterly, this order would be ascending, unless the whole system had been subjected to an overturn. The order was as follows:

Taconic slate, sparry limestone, magnesian slate, Stockbridge limestone, granular quartz.

In the first volume on the Agriculture of New York, the preface to which is dated December 30, 1846, Dr. Emmons describes the members of the Taconic system in the following order:

Black slate, with two species of trilobites. Not here certainly regarded as belonging to the Taconic.
Taconic slate with its subordinate beds, with various markings referred to Nereites. Cited from Brunswick, Rensselaer county.
Sparry limestone.
Magnesian slate. (Talcose slates of 1856.)
Stockbridge limestone.
Brown sandstone or granular quartz.

5. *Palæontologic characters.* In the original characterization of the system, it was supposed to be destitute of fossils. This was made one of the points of distinction from the rocks of the Champlain Division. In the agricultural report, however, the author, besides describing and figuring two genera of trilobites—*Atops trilineatus* and *Elliptocephala asaphoides* (now known as *Conocephalus* and *Olenellus*)—from the Black slate, described and figured eleven species of Nereites and two fucoids; also one crushed tube supposed to be that of an annelid. Subsequently, many more species have been discovered in the rocks embraced by Dr. Emmons in the Taconic system.

6. *Original grounds of the Taconic system.* (1). Lithological: Compared with the palæozoic rocks, they are not the same, nor the same in a metamorphic state. Nor do the different lithological divisions occur in the same order as the divisions of the Champlain group from which they might seem to be derived by alteration. Further, they are distinguished by the presence of hæmatitic masses, while the iron of the Silurian is argillaceous or oölitic. The black oxide of manganese is another

distinction. As expressed in the agricultural report, "The members of the Taconic system have a different arrangement. The sandstones, limestones and slates are not only different in their relative position but they are much thicker than those with which they have deen supposed to be identical in the New York system."[1]

Compared with the primary rocks they are less crystalline, and in constitution, the rocks themselves differ, and also inclose a different range of accessory minerals. Actinolite, epidote, titanic and auriferous sulphuret of iron and graphite are confined to the primary. Further, the minerals of the Primary have a uniform connection with the rock masses; they are contemporaneous with them. There are rarely any cavities around them; but they are closely invested on all sides by the materials of which the rock is composed. On the contrary, in aqueous rocks, minerals occur in pre-existing cavities, and they are usually composed of substances more or less soluble under one or more conditions.[2]

(2). Stratigraphic unconformities: These appear not to have been distinctly brought out before 1846. In the agricultural report, page 56, three sections are delineated, in which the Calciferous sandstone is shown to overlie the Taconic strata unconformably. In plate XVIII, six sections are given in detail, showing the unconformable relations of the Taconic and New York systems. The details of the report point out marked unconformities with the underlying Primary masses.[3]

(3). Palæontologic unconformity: In the first enunciation, the Taconic beds were supposed differentiated from the New York system by their complete destitution of organic remains. At the date of the agricultural report, Dr. Emmons' view on this point was embodied in the following conclusion: "The Nereites and other fossils of the Taconic slates are unknown in any of the members of the Champlain group; the mollusca of the New York system are also wanting."[4]

In subsequent publications, the author of the Taconic system

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[1] Report on Agriculture, p. 168.

[2] Report on the Second District, pp. 138-141.

[3] See, for instance, p. 111.

[4] Agricultural Report, p. 108.

embodied the results of later studies both by himself and others, and the stratigraphic and palæontologic grounds of the system were much more fully, accurately and effectively stated. But it is only necessary in this examination to learn distinctly what was the founder's view in the institution of his system.

7. *Central conception of the founder of the Taconic system.* From a study of the oldest documents treating of the Taconic system, it is not difficult to discover their essential purport. The central conception of Dr. Emmons was a system of sedimentary fossiliferous rocks underneath the Champlain group. To be a system it must possess distinct stratigraphic limitations both above and below, and must contain the records of a system of life unlike that of the overlying system. Quite possibly, the original propounder had not attained exact views in reference to the true limitations of his systems either above or below. He entertained the opinion that the Potsdam sandstone was not embraced in the Taconic; in that he may easily have been mistaken. He seems to have entertained the conviction that his system extended downward to the crystalline schists, and held what he termed "the absolute sedimentary base;" in this he may also have been mistaken. The upper and lower limits concern, however, only the border land of a great conception which with him was entirely original—a vast downward extension, below the base of the New York system, of the records of marine sedimentation and of life.

II. Is there a real sub-Silurian system?

1. That the Potsdam sandstone, the base of the New York system, does not mark the lowest limit of the record of life, is now a fact so notorious as to constitute one of the elementary truths of the science.

2. An extensive fauna of sub-Silurian life has been brought to light within the very area over which Dr. Emmons extended his system. Many of these forms have been discovered in the very strata embraced in the enumeration of the Taconic formation. Most of them have been signalized from strata lying on the eastern side of lake Champlain, and northward toward Quebec—the Swanton slates, the Phillipsburg group, the Georgia slates and the St. Albans group—called collectively

the Georgia group, by Walcott. On the west side of the state boundary, at Bald mountain, in Washington county, and near Saratoga, occur fossils belonging to sub-Silurian types, and therefore Taconic; but the latter are found in the upper portion of the Potsdam group, and hence carry that group into the Taconic, in spite of Dr. Emmons' early opinions. It may be added that fossils of the same significance have been found also by Marcou, at Keeseville in New York; and if the red sandrock of Vermont is in continuity with the granular quartz, which, according to Walcott, contains primordial fossils, the place of the Potsdam is fixed in the Taconic.

The discovery of sub-Silurian remains in Massachusetts, New Brunswick, Newfoundland, Nevada, Colorado, Mount Stephens, Northwest Territory [recently, by Dr. Rominger], and other regions in America, require no more than the mention.

I quote a single passage from Mr. C. D. Walcott, in one of those careful and elaborate memoirs which have so enriched the literature of American geology: "Of the presence of a well-defined geologic system beneath the strata characterized by the second fauna of Barrande, or the Trenton fauna [including the Chazy and most of the Calciferous] of North America, on the North American continent, there is no question. The geologic sections given in this paper show it to have a total thickness of over 18,000 feet." [1]

It will give a clearer conception of the justness of this verdict of Mr. Walcott to reproduce some of the results embodied in his last and very important memoir,[2] a continuation of which is promised. He gives us a colored map of the original Taconic region through Vermont, Massachusetts and New York. The so-called Georgia group, which is sub-Potsdam, is represented by three colors. These collectively form a band beginning at the northern boundary of Vermont, and extending without a break, through western Massachusetts to Columbia county, New York, where information seems to be wanting. But be-

[1] Bull. U. S. Geol. Surv. No. 30, p. 11; also Am. Jour. Sci. (3), xxxiii, 139, Aug., 1886.

[2] Am. Jour. Sci., (3), xxxv, pp. 229-242 and pp. 307-327, with a colored map and a section. To be followed by a memoir on Washington county, N. Y.

yond this it is known with interruptions as far as Litchfield and New Haven counties, Conn., and Dutchess county, New York. From the Canadian border to Columbia county these rocks cover a breadth of eight to twenty miles. Mr. Walcott states that he knows the occurrence of fossils at over one hundred localities within the area of the Georgia terrane. All these rocks and all these fossils are older than the Potsdam. They lie within the area of the original Taconic, and the fossils are all types of the first fauna of Barrande. I consider these results conclusive of the right of the Taconic system to full recognition.

A sub-Silurian is therefore well established at the present day. This is precisely what Dr. Emmons contemplated and anticipated.

III. Was Dr. Emmons anticipated by other investigators?

1. *Limits of the Silurian.* In 1839, Sir R. I. Murchison published his "Silurian System," in which he gave an exposition of a system of fossiliferous rocks underlying what is now known as the Devonian system. The name Silurian had been employed by him since 1835. It was intended to embrace all the known fossiliferous rocks below the Devonian, but at that time little was known of remains below the horizon of the Caradoc. In 1834 Murchison had recognized the extension of the sedimentary series as far down as the "unfossiliferous graywacke of the Longmynd."[1] In his Silurian System, and in Siluria [1854] the Longmynd and Llanberis rocks are excluded from the scope of the Silurian system, because destitute of fossils, so far as known in Great Britain. The Longmynd were characterized as "bottom rocks." But even in 1844 two species of *Oldhamia* had been described from beds in Ireland equivalent to the Longmynd of Shropshire and South Wales. The Silurian therefore, terminated downward in the midst of the fossiliferous column.

2. *Position and rights of Cambrian.* In 1836, the name Cambrian was bestowed by professor Sedgwick on a series of strata occuring in North Wales, believed to occupy a position

[1] Proc. Geol. Soc. London, II, 11, Jan., 1834.

inferior to that of the series designated as Silurian by Murchison. But it subsequently appeared that the upper portion of them was the equivalent of strata in the continguous county of Shropshire, which Murchison had already annexed to his Silurian, under the designation of Lower Silurian—assuming that one systemic designation could properly include a palæontologic and stratigraphic break as abrupt as that between the "Upper" and "Lower" Silurian. The Cambrian of Sedgwick extended from the top of the Bala rocks to the bottom of the Llanberis. Their position was below the Silurian of Murchison as first conceived by himself, but was embraced in what may be called the Silurian annex.

3. *Stratigraphical relations of the Cambrian.* Meanwhile, M. J. Barrande was at work on the geology of Bohemia. In 1851, appeared his publications in the *Bulletin de la Societe geologique de France*, and in 1852, the first volume of his *Systeme silurien de la Boheme.* In these was introduced his classification of older rocks into stages denoted by the letter A, B, C, etc., and the more important recognition of certain great palæontologic breaks, separating a succession of distinct systemic faunas, thus:

E to H.	Third fauna, 900 feet.
D.	Second fauna, 6,000 feet.
C.	Primordial fauna, 1,200 feet.
A and B.	Azoic schists, 9.000 feet.

When the same strict principles of palæontologic classification came subsequently to be applied to the oldest rocks of Great Britain and America, the following conclusions were apparent:

(1). The true primordial fauna had not been embraced in the proposals of either Murchison or Sedgwick. The rocks containing this fauna in Bohemia extend "on an average, ten thousand two hundred feet" below any fossiliferous strata then known to Murchison or Sedgwick. Barrande embraced this entire extension under the name "Silurian," because he had then (1852) no knowledge of what had been done and proposed by Sedgwick in 1836, or by Emmons in 1842.

(2). The "sedimentary base" of the Taconic system signalized by Emmons in 1842, and synchronized with his "palæozoic base," fixed in 1844, did reach down to the primordial fauna of Barrande, and included it. So that Emmons was guided by a

true insight in 1860, when he wrote: "The upper part of the Taconic is equivalent to Barrande's primordial group."[1] The Cambrian, therefore, laid no claim to the chief ground covered by the Taconic.

4. *Stratigraphical relations of the Huronian of Logan.* The Huronian system was proposed by Sir W. E. Logan, in 1855, for some Canadian strata located north of lake Huron, and supposed to extend from the base of the Potsdam sandstone downward to the crystalline schists. His conception was therefore identical with that of Dr. Emmons in proposing the Taconic system. In the case of the Taconic, strata containing primordial fossils older than the Potsdam have been found within the geographical limits originally assigned to the system. In the typical region of the Huronian, no fossiliferous strata have as yet been discovered, and it remains to show what part of the Taconic they correspond to. In saying this, I employ Taconic as originally conceived by Emmons—a great system extending down to the crystalline schists. It may be said, however, as the Huronian strata are now known to rest unconformably on lower strata which overlie the crystalline schists,[2] so, undoubtedly, adequate knowledge of the base of the Taconic, will show the inadmissibility of its claim to extend down to the crystalline schists. At its base, the Huronian stands, therefore, at the present time, precisely in the position of the Taconic, and is superseded by it. Above, it remains to determine whether the typical Huronian reaches up into the zone of the primordial fauna, which, as stated, the Taconic includes. In the basin of lake Superior, the so-called Kewenian series intervenes between schists identified with the Huronian and strata believed to belong to the age of the Potsdam sandstone. These hold, therefore, the stratigraphical position of the St. Albans, Phillipsburg and Swanton groups, with their primordial fauna. As beds having an igneous history, they may sustain some such relations to primordial life as the porphyry of Bohemia, whose eruption terminated the existence of the primordial fauna, before it had

[1] Letter to M. J. Marcou, in *The Taconic system and its position in stratigraphical geology*, by Jules Marcou, Proc. Am. Acad., new ser., vol. xii, p. 184.

[2] A. Winchell, in Amer. Jour. Sci., Oct., 1887, p. 314; *American Geologist*, Jan., 1888, pp. 14-24.

attained so prolonged a history as in some parts of North America. Whatever the facts may be as to the upper limit of the Huronian, the designation commonly employed for the system is clearly superseded by Taconic. This was the understanding of Dr. Emmons, though the contention seems to have dropped almost out of remembrance.[1] In 1860, in a letter to M. Marcou, speaking of a communication to the American Journal of Science, which was refused publication, he says, "I claimed that the Huronian was only the Taconic system." In 1861, he wrote, "It was ten years ago, I think, when I claimed Logan's Huronian system as nothing more than the Taconic." Unless, therefore, we find the zone of the primordial fauna interposed between the typical Huronian and the Lower Silurian, showing the typical Huronian to stand for a zone of truly azoic sediments, it would appear that the name Huronian ought to be dropped out of use.

IV. Validity and scope of the Taconic.

1. *Grounds of opposition to the Taconic.* It was from the beginning maintained by certain North American geologists, to whose judgment most of the others deferred, that the rocks within the area of the Taconic as defined by Dr. Emmons, were newer than the Potsdam sandstone, instead of older; and that their more ancient aspect than the other strata of the same age was due to metamorphism. It is not needful to consider with whom this view originated, nor to recall the discussions which have taken place. It may be granted that palæontological and structural investigations, carried on in the region south of lake Champlain, have succeeded long since, in showing that a considerable mass of strata embraced by Emmons in the Taconic, lies really within the New York system. It is not known, however, that no genuine sub-Potsdam Taconic occurs within the same area. Indeed, it has been shown while I write, that the quartzite series contains sub-Potsdam fossils, and extends from near Bennington in Vermont to Williamstown, Mass., and Stissing mountain in Pine Plains, Dutchess county, N. Y.[2]

[1] This equivalence was urged by N. H. Winchell in his vice-presidential address before the Am. Assc. Adv. Sci. in 1884.—[Ed.]

[2] Walcott: *The Taconic System of Emmons.* Am. Jour. Sci., 3, xxxv, pp. 234-6.

As to the region east and north of lake Champlain, investigations equally assiduous have succeeded in showing that a considerable area is occupied by strata older than the Potsdam; and that they contain a fauna of a truly primordial character, whose geological position is lower than any fossiliferous strata known to either Murchison or Sedgwick. Nothing more is needed than this simple statement.[1]

Thus the investigations of forty years have shown that the central conception of Dr. Emmons was founded on fact. This was simply a system of fossiliferous strata older than the New York system. Such system has been demonstrated by the researches of many investigators—Perry, Barrande, Billings, Marcou, Ford and Walcott. "To him belongs," says Walcott, "the credit of recognizing and describing the Middle Cambrian series of North America, as a distinct formation, both on structural and palæontologic grounds. * * * The central idea of which [Emmons' proposal] that a great series of Palæozoic strata, of pre-Potsdam age, existed east of the Hudson river shales of the valley of the Hudson and lake Champlain, we now know was correct."[2]

It signifies nothing that others—Dana, Dwight, Walcott[3]—have shown that some strata of the New York system are included among those described by Dr. Emmons as Taconic. Any amount of demonstration of such a proposition has no bearing against the conclusion that sub-Potsdam strata do exist, as Emmons alleged, and in the region originally circumscribed by the founder of the Taconic.

Mr. Walcott, who seems disposed to do justice, expresses regret that he cannot apply the term Taconic to the series of fossiliferous strata older than the Ordovician, the middle division of which Emmons distinguished "on structural and palæontologic grounds." But, if we do so, he says, "the great lower division described by Emmons as the typical Taconic, will be dropped entirely, and the Upper Taconic, which is not now

[1] The objections urged against the Taconic are discussed seriatim by my brother, N. H. Winchell, in *American Geologist*, March, 1888, pp. 162-72.

[2] Walcott: Bull. U. S. Geol. Surv., No. 30, p. 65.

[3] See especially, Walcott's most recent paper, Am. Jour. Sci., (3), xxxv, 229-42—still to be continued.

known to occur in the Taconic area, would be taken as the true Taconic, which it does not appear to be, although Dr. Emmons included the Black Slate in it in 1847."[1]

The above paragraph, if I successfully penetrate its meaning, seems to me at variance with good reasoning. If Dr. Emmons characterized well the middle division of Mr. Walcott's Cambrian, it seems to me the two ends must go with the middle into the Taconic, whether Emmon's established a proper order within the Taconic or not. If, in continuing, the writer means that the great lower division of the Taconic was "described as the typical Taconic," I should beg to differ, since the greatest abundance of Taconic characteristics cited by Emmons pertained to the Upper Taconic — as finally he designated it. The Lower Taconic was originally described simply as a part of the Taconic, and if it cannot hold its place a large body of Taconic rocks remains. Lastly, with the statement that the Upper Taconic "is not now known to occur in the Taconic area," I beg again to differ, since the whole "Georgia group," as defined and mapped by Walcott, and ranged in the middle division of his Cambrian, falls within the original Taconic area. The Upper Cambrian of Walcott was excluded from the Taconic, but it appears that its palæontological affinities carry it there.

Mr. Walcott's position will be made plain by the following compilation of results embodied in his last paper, to which reference has already been made:

Parallel with Walcott's stratigraphy I have placed the principal members of Emmons' system, showing the singular stratigraphical disorder into which he fell. At the right hand, the Taconic and Cambrian stand as I would here propose.

It is chiefly in consequence of this unfortunate confusion that Mr. Walcott concludes the term Taconic ought to be dropped out of use. It seems almost presumptuous to differ with so thorough and candid an investigator. Mr. Walcott seems to have completed happily the difficult work on which professor Dana has so skillfully labored for several years. The results possess the highest scientific value, for the labor has been one of exceptional

[1] Bull. U. S. Surv., No. 30, p. 65.

difficulty, requiring palæontologic and stratigraphic skill of the highest order. A flood of light now shines on a question long dark. We can understand that the defenders and the opposers of the Taconic have all had good reasons for their claims—if they had not made them so exclusive. American geology owes

WALCOTT.		Walcott's stratigraphy within the Taconic area.	Emmons' equivalents.	WRITER.
ORDOVICIAN.		*Hudson terrane.* 4. Shales and sandstones. Smooth shales with Graptolites. 6. Red, black and green shales, cherts and sandstones, faulted in between two parts of terrane No. 5. With Graptolites.	*Lower Taconic.* Talcose slates. Essentially a repetition of Lower Silurian.	CAMBRIAN.
ORDOVICIAN.		*Trenton-Chazy-Calciferous.* 3. Limestone and marble, both sides of the Taconic range. Determinations worked out chiefly by Dana.[1] Fossils investigated by Wing, Dana and Dwight, and by Walcott.	*Lower Taconic.* Stockbridge limestone. *Super-Taconic.* Chazy at Bald Mt.	CAMBRIAN.
CAMBRIAN.	UPPER.	*Potsdam group.* 2. Talcose and silicious slates, sandstones and limestones. 2,000 feet. Saratoga county. { 2. Limestone with Potsdam fauna. 1. Massive sandstone, with typical Potsdam fossils farther north. Washington county. { 3. Calciferous, interbedded in shales. 2. Limestone, with Potsdam fauna. 1. Potsdam sandstone. Dutchess county. { Limestone with Potsdam fossils.	*Super-Taconic.* Calciferous. Potsdam. Overlapping by faulting.	TACONIC.
CAMBRIAN.	MIDDLE.	*Georgia group.* 1. Quartzyte series. Shore-line deposit, contemporaneous with No. 5. Not as low as lowest of No. 5. Bennington and Pownal, Vt., North Adams, Mass., Stissing Mt., Dutchess Co., and elsewhere. 5. Georgia terrane. Slates, shales and interbedded limestones and sandstones 14,000 feet. Off shore deposits. Fossils at over 100 localities in the typical Taconic area.	*Lower Taconic.*—*Upper Taconic.* Granular quartz. — Slates, Shales, limestones, sandstones	TACONIC.
CAMBRIAN.	LOWER.	*Paradoxides fauna belongs below.*		TACONIC.

Mr. Wallcott gratitude and honor for what he has accomplished. But I am inclined to the opinion that it is the very severity of his scientific method which prevents his due appreciation of the bearing of the facts which he has been foremost to bring to

[1] Amer. Jour. Sci., 1872 to 1887.

light. Mr. Walcott has gone farther than a comprehension of the elements of the Taconic question requires. He has followed Taconic history too far, and with too much minutiæ of criticism for a broad, judicial contemplation of the essential problem—though not, I repeat, too far for the ends of science. He has disclosed many egregious errors which, at first view, are rather confounding, and suggest that with so much mixture of error, confusion and truth, it may be best to abandon Taconic to the records of the past. But when we rise from the study of these perplexing and discouraging features of Taconic history, and generalize our field of view again, we observe that after all, they are but details, subordinate to the grand fundamental conception of a sub-Silurian and sub-Cambrian system of rocks and of life. As long as Dr. Emmons' central conception remains valid, we must not be too exacting in reference to the details of his determinations. Nor must we mercilessly hold to the standards of to-day, the conclusions of a research prosecuted over forty years ago, when primordial palæontology scarcely had existence either in America or Great Britian; and when stratigraphic and petrographic methods of research were generally no more thorough than those which Emmons so long, and so patiently, and so full of conviction, pursued. Unfortunate circumstances surrounding him gave an adverse set to opinion, which no efforts of his friends could change during his life-time. Those who knew Dr. Emmons personally can understand some of the reasons of this. But personal dislikes are poor arguments, and they become contemptible when known only as traditions. We are concerned at this day, only for truth and justice. If we can discern the grand outlines of truth and justice, we shall not be frightened away by some details of error and misconception. Viewing the subject in a large way, with a mind free from prejudice and prepossession, I feel borne to the conviction that the Taconic system has a right to stand.

2. *Defenders of the claims of the Taconic.* American defenders I will not cite; but I wish to quote the judgment of M. Barrande, whose competency perhaps none will question:

"At its origin, that is to say, from 1838 to 1844, this Taconic system was presented as founded on petrographic and stratigraphic observatiohs, and constituted simply the *sedimentary*

base, according to the American expression. It was still without any characteristic fauna. 'But in 1844, Dr. Emmons having discovered in this formation fossils before unknown, his Taconic system for him represented the *palæozoic base.*

"This expression, used on the other side of the Atlantic, is evidently equivalent to that of "primordial fauna,' which I have applied to the trilobitic group, the oldest of Bohemia, defined for the first time in my *Notice preliminaire*, in 1846. It is known that the *Lingulæ* which characterize the horizon of Lingula flags in Wales, that is, the Cambrian region of England, were only discovered by Mr. Davis in 1845 [Siluria, 2d ed. p. 43, 1859.]

"In comparing these dates, it is clear that Dr. Emmons had first announced the existence of a fauna anterior to that which had been established in the 'Silurian System' as characterizing the Lower Silurian division, and which I have named second fauna. It is then just to recognize this priority, and I think it all the more fitting to state it at this time, that it has not been claimed to this day."[1]

I agree with Marcou that "it is evident that if Barrande had seen the memoirs of Emmons when they appeared, he would have used the name "Taconic" to designate all that lower part of the most ancient strata of Bohemia which, having nothing better, he called Divisions A, B, and C of the Lower Silurian.[2]

The other judge whom I desire to cite is M. Dewalque, the general secretary of the committee on uniformity of nomenclature. At the meeting of the International Congress at Berlin, in 1885, after giving the opinions of various national committees in reference to the classification of the lowest Palæozoic rocks, M Dewalque said:

"Since the receipt of the reports of the national committees, the question to be decided has become complicated. M. Jules Marcou, in an important work published by the American Academy of Science and Arts, and entitled "*The Taconic System and its position in Stratigrapic Geology*," has vindi-

[1] *Documens anciens et nouveaux sur la Faune primordiale et le Systeme Taconique en Amerique.* Bull. Soc. geologique de France, 2 ser., tom., xvii, p. 225. 1861.

[2] Proceedings Amer. Acad., xii, 252, 1885.

cated the priority of the term Taconic, of which the Cambrian above mentioned [of primordial fauna] would be the equivalent. To us the question seems demonstrated. In such a case, the term Cambrian would be employed to replace the Ordovician, and the name Silurian would come back by right to group 6. If we be not in error, this solution would avoid many difficulties."

3. *Position and Equivalences of the Taconic system.* I forbear the presentation of any extended table of sub-divisions and equivalents of the Taconic system. After the presentation of Mr. Walcott's results, it is scarcely necessary to do more than refer for comparison to the table of M. Marcou in his last publication.[1] I conclude by saying, that in my opinion, the proposal of M. Dewalque is entirely feasible and just. The term Ordovician has no need to appear in American geology. It stands, in England and America, for the rocks first named Cambrian; and Taconic stands for the older strata holding the primordial fauna. I favor, therefore, the following arrangement:

III. Silurian [=Upper Silurian, containing 3d fauna.]
II. Cambrian [=Ordovician, containing 2d faun.]
I. Taconic [Containing primordial fauna.]

A CONTRIBUTION TO THE ARCHÆAN GEOLOGY OF MISSOURI.

BY ERASMUS HAWORTH.

PART II.

B. THE PORPHYRIES AND PORPHYRYTES.

The porphyries and porphyrytes constitute at least nineteen-twentieths of the massive rocks of Missouri. They are the most extensively developed around Pilot Knob, and Iron Mountain. The different varieties grade into each other by almost imperceptible transitions, not only in the character of the rocks, but also with reference to the geographical areas over which they are exposed. In general the most acid types are near

[1] *On the Use of the Term Taconic*, Proc. Soc. Nat. Hist., Boston, xxiii, Mar. 2, 1887, pp. 343-55.

Pilot Knob. As we pass to the south and southeast we find them becoming more and more basic.

(*a*) *Mineralogical composition.*

The minerals which occur in sufficient quantities to form any considerable proportion of the rock masses are quartz, orthoclase, plagioclase, and epidote. The list of accessory minerals is much greater. Some of these are original constituents, and some are of secondary origin. They are, iron-oxides of different kinds, chlorite, leucoxene, calcite, apatite, fluorite, pyrite, zircon, rutile?, muscovite, and piedmontite. It is quite probable that biotite, or hornblende, or augite has been present in considerable quantity in the more basic varieties, and that it was the source of the greater portion of the epidote so abundant in some of the porphyrytes; but no instance was noticed in which either of these three was present, even in the smallest quantity.

It is interesting to note that the general mineralogical composition of the porphyries is almost identical with that of the granites. The absence of biotite and hornblende and augite in the porphyries has already been mentioned and a probable explanation given. Topaz would be expected only where fumerole action has existed, and therefore its presence or absence has but little, if any, bearing on the probable original composition of the rock magma. Zircon is comparatively rare in the porphyries, and iron-oxide is much more abundant than in the granites. Otherwise there is almost no difference in the mineralogical composition of these two rock families as they occur in Missouri.

(*b*) *Special description of minerals.*

Iron-oxide. Little black grains of iron-oxide—probably magnetite in most instances—are scattered all through every thin section of the porphyries examined. The most common size of these grains is 0.05 mm, but some of them are much larger, and others are very much smaller. Quite frequently the very little grains are arranged in lines, and when looked at with an ordinary magnifying power would be taken for threads or hair-like inclusions, but when examined with a high power their true character is revealed.

In some localities the iron-oxide is unevenly distributed

through the rock mass, so that it gives the rock a spotted appearance. A portion at least, of the so-called fragmental rocks owe their spotted color to this cause.

Orthoclase and plagioclase. One of these minerals is always present and in many cases the two exist side by side. The presence or absence of quartz does not determine the relative amounts of them. In the more basic varieties the plagioclase is labradorite or bytownite, and in the more acid ones it is oligoclase or andesin, as is shown by their specific gravity determinations. In specimen number 273 the results obtained were 2.716, and in number 223 it was 2.665. It is interesting to note that number 223 has no porphyritic quartz whatever, while number 273, with the basic feldspar, has a great deal of quartz in the very coarse ground mass by the side of large quantities of epidote. Usually the feldspars are quite fresh. When altered they yield the ordinary products of alteration.

Epidote. This mineral is present in varying amounts in a great many of the porphyries. Its irregular distribution in the rock-mass—often occurring in partially decomposed feldspars—and the total absence of crystalline form indicate that it is of secondary origin and suggest that probably it was mainly derived from an iron silicate which has been wholly changed so that no vestige of it can now be discovered. The epidote varies from the smallest grains to those an eight of an inch in diameter. As we pass south from Pilot Knob the amount gradually increases. In some places, particularly at the Piedmont quarries, it is sufficiently abundant to give the rock a spotted, dark green color.

Piedmontite. This rare manganese epidote exists in small quantities in the porphyries at different places. It is most abundant at the quarries four miles southeast of Anapolis, but traces of it were seen in specimens from Piedmont; and, judging from the similarity of different rocks, it should be looked for at all those quarries along the road between Hogan and Piedmont. Specimens numbers 278 and 279 have the largest amount of the mineral of any examined. They are reddish, coarse-grained porphyrytes, consisting essentially of a quartz and plagioclase groundmass through which iron-oxide, epidote, and the piedmontite are scattered. The porphyritic constituent is plagioclase. The pied-

montite is in small, irregular grains which, while not being in well-developed crystals, are often elongated sufficiently to show their axial directions.

In order to determine whether or not the mineral was piedmontite it was subjected to the following examinations. A careful microscopic examination was made, which showed that a portion, at least, of the grains extinguished parallel to their greatest elongation. Piedmontite is elongated parallel to crystallographic b, and all sections in the zone of the basal-pinacoid and orthopinacoid planes would have parallel extinction. The mineral is strongly pleochroic, giving $\mathfrak{a}$ = carmine, $\mathfrak{b}$ = amethyst, $\mathfrak{c}$ = orange. These correspond quite well with the colors given by Laspeyres[1] for piedmontite from St. Marcel. The index of refraction is quite strong, as is shown by the apparent thickness of the mineral in the slide. A quantity of the mineral was isolated by first making a separation of the portions of the rock heavier than 3.1 by means of the Thoulet solution, and boiling the powder thus obtained in strong chlorhydric acid, which dissolved the iron oxides, leaving the piedmontite mixed with epidote. During the boiling examinations were made to see if free chlorine were given off, which would have been the case had manganese dioxide been present. None whatever could be detected. The residue looked quite red, and gave a strong reaction for manganese.

Now the only two minerals with which piedmontite is liable to be confused are withamite and thulite, two varieties of epidote. Rosenbusch, in the last edition of his petrography, is inclined to class with withamite all the red epidotes which he mentions as occurring in porphyries—see p. 472. Lacroix[2] has investigated the optical properties of withamite and thulite, and finds that they correspond very closely with those given by Laspeyres for piedmontite. Thus, all three are positive; the three pleochroic colors are the same for the three minerals, and have the same arrangement in piedmontite and withamite, but different in thulite. The colors in piedmontite, however, are a little more strong than in either of the others.

The different text-books examined which mention withamite

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[1] Zeitschr, für Kryst, vol. 4, pp. 435-468.

[2] Bull, de la Soc. Francaise de Min., p. 75.

give it as a manganese free epidote. But in Prof. Heddles'[1] complete analysis of the mineral he finds 0.138 per cent. of MnO. I did not succeed in isolating a sufficient amount of the Missouri mineral for a quantitative analysis, but judging from the results of the qualitative examinations there is little chance to doubt the presence of manganese in sufficient quantity to make the mineral a piedmontite. The occurrence of this rare mineral in Missouri is quite interesting. So far as known to the writer it has thus far been reported from but three different localities; St. Marcel in Piedmont, Italy; Jacobsberg in Wermland, Sweden; and from Japan. The last named locality was recently reported by Prof. Koto[2] who describes it as occurring very abundantly in the Archæan schists and gneisses.

(*c*) *Structure of the porphyries.*

The structure of the groundmass has always been regarded as a matter of first importance by students of porphyritic rocks. This groundmass may be holo-crystalline, semi-crystalline, or glassy. Rosenbusch divides the first of these into the *micro-granitic* and *granophyric* and designates the second and third respectively by the terms *felsophyric* and *vitrophyric*. In the Missouri porphyries a third class of the holo-crystalline groundmass is so well represented that it should receive special notice. Before describing it, however, a short discussion of the different possibilities in a holocrystalline groundmass may be of interest. The following is taken from the lecture notes of Prof. G. H. Williams, who kindly consented to my copying it:

"A holocrystalline groundmass contains no amorphous or unindividualized matter whatever, and independently of differences occasioned by variations in the fineness of grain, three quite distinct types of holocrystalline structure are distinguishable. These three types are conditioned by the mutual relation of the quartz and feldspar crystals which compose the groundmass. In the first place they may be wholly independent, thus giving rise to a granular aggregate which is well designated by the term *Microgranitic Structure*.

In the second place a granular effect may be produced by the complete interpentration of two individual crystals of the same size. In this case

[1] Mineralog. Magazine, vol. 5. p. 15.

[2] Journal of the College of Science, Imperial University, Tokyo, vol. 1, part III, pp. 303-312.

—due to the simultaneous crystallization of the two minerals from the magma—all the parts of the same individual, no matter what the size or shape, must have exactly the same opticalorientation, and must hence extinguish the light between crossed nicols together. Such a structure is termed, according to the particular form it assumes, *micropegmatitic* or *granophyric*. In the third place a single large crystal of one of the two constituents of the groundmass may be filled with much smaller, irregularly arranged grains or crystals of the other. This would also give the general effect of a finely granular structure, although it is essentially different from either of the others above mentioned."

This type of structure apparently has never received attention as a variety of the holocrystalline groundmass in porphyries, but it is admirably exhibited in the Missouri rocks. It may perhaps best be designated as the *pœcilitic structure*, being strictly analogous to the mottled appearance described by this term by Prof. Williams in certain coarse-grained peridotytes, where large hornblende crystals are dotted through with grains of olivine and hypersthene.[1]

We may therefore divide the Missouri porphyries, in regard to the structure of their groundmass, as follows:

I. Holocrystalline.	(1)	Microgranitic.
	(2)	Granophyric.
	(3)	Pœcilitic.
II. Semicrystalline.	(4)	Felsophyric.
III. Glassy.	(5)	Vitrophyric.

1°. *The microgranitic structure:* This class includes more than half of the different kinds of porphyritic rocks of the whole area. It is represented in the quartz-porphyries, the quartz-free-porphyries, and the porphyrytes. The porphyritic individuals in it are sometimes corroded, but not so frequently nor so badly as in those with felsophyric and vitrophyric structures. The size of the individual crystals in the groundmass varies greatly. In the coarsest grained ones the constituents can readily be determined to be quartz, orthoclase, and plagioclase, the particular associations depending on the nature of the rock. From this degree of coarseness they pass into the microfelsytes by almost imperceptible gradations.

2°. *The granophyric structure:* This is so well known it

[1] See the Peridotites of the Cortland series. Am. Jour. Sci., (3). xxx, p. 30, Jan., 1886, and xxxiii, p. 139, Feb., 1887.

needs no special description here. It is represented in comparatively few localities in this area. Some of the coarsely crystalline varieties which are as nearly granites as porphyries belong to this type, such as number 268, from near Hogan. It is very common to find a porphyritic individual of feldspar or quartz that has served as a nucleus around which the radiating rays of the granophyre are clustered. Fig. 2, pl. 1, from number 410, the wall rocks of the big dyke at the Tin Mines, show this quite well.

3°. *The pœcilitic structure.* In many of the fine grained rocks the individual grains cannot be seen unless highly magnified, but if the section be revolved on the stage of the microscope while the nicols are crossed the whole field is broken up into different areas, each of which will change alternately from dark to light. A great many little specks of feldspathic material are scattered through the whole mass, but they seem to be entirely irregular in their arrangement. Fig. 1, pl. i is an attempt to represent this structure as seen in number 211, taken from the north side of Shephard mountain, about three-fourths of the distance from the base to the summit.

As the crystallization increases these different areas increase in definiteness, so that in the more coarse-grained varieties their true character can readily be determined. Fig. 3, pl. i, shows a coarse-grained porphyry, number 347, in which this structure is well represented. A given quartz crystal is entirely surrounded by a larger area of a mixture of quartz and feldspar in which the quartz is oriented with the central crystal. In reality, then, this is a large quartz crystal, a portion of which has a great deal of the feldspathic material as an impurity scattered through it in an irregular manner. In some cases the feldspar is well crystallized, and projects into the quartz crystal, as shown in the same figure. This, then, is the explanation for all of these areas into which the field breaks up as the stage is revolved. Each one represents a quartz or feldspar crystal throughout which the feldspar material is irregularly scattered. The degree of crystallization determines the definiteness of outline of each area, and the amount of light which passes depends largely on the distribution of the feldspar material.

4°. *The felsophyric structure.* A large proportion of the

porphyries of this area have a structure corresponding to the popular microfelsitic, or felsophyric. Some of them are exceedingly fine-grained, and differ from the microgranites in this respect only; others more closely resemble those with the pæcilitic structure; while still others are rocks which have many spherulites scattered through them. Many of them have the flow structure well developed, and it is not unusual to find associated in one slide the spherulites, the flow structure, and a very fine-grained micro-granitic structure.

All of the rocks of this structure are very compact and have a flinty fracture. They are very abundant around Middlebrook, Pilot Knob, and many other localities.

5°. *The vitrophyric structure.* Rocks of this class originally were vitrophyres, but the process of devitrification has progressed so far that at present little if any of the isotropic ground mass remains, yet the structure is such there can be no reasonable doubt regarding their original condition.

About two hundred yards north of the station at Arcadia a large mass of porphyry is exposed by the roadside. Specimens 202 and 203 are from this place. They have badly corroded quartz and orthoclase crystals, and have the flow structure well developed in the ground mass. Less than a fourth of a mile away, at the foot of the hill northeast of the Methodist church is another rock, number 204, which has the flow structure as well developed as any modern volcanic rock. On the south side of Shepard mountain, about half way from the base to the summit, there are a number of thin, even layers less than two inches thick which were thought to be sedimentary rocks, but which, upon examination with the microscope, proved to be lava flows. Number 216 is from this place. Many other localities of similar rocks could be given, but these will serve for illustration.

The rocks representing these fine types of structure have no sharp lines between them, but they pass from one extreme to the other by many intermediate grades.

A comparative study of the porphyries and granites of this district reveals the interesting fact that there is no sharp division line between the two, at least so far as can be judged from the hand specimens. The question naturally arises, "Do we have

here in Missouri an illustration of the gradual transition from a holocrystalline, coarse-grained rock through the fine-grained ones into those which originally were vitrophyres?" If the field relations strongly corroborate the evidence obtained from the hand specimens it will add greatly to the probabilities in favor of the correctness of an affirmative answer. Let us see what the facts are.

There are two important points however which should constantly be kept in mind while considering this question. 1°. The present elevations may, and probably do, differ from those which obtained during the period of solidification of the rock masses. The time has been so long that surface erosion and oscillations may have somewhat changed the original contour. 2°. The surface of this original eruptive mass during the period of solidification very probably was quite uneven. It is the distance below this original surface at which any given rock mass solidified that should determine its structure, and not necessarily its relation to the present surface.

It is therefore manifest that in certain cases there may be apparent reversions of the rule that the farther below the surface a rock exists the more coarsely crystalline it is. Such cases are not lacking. Specimen number 214, from the very summit of Shepard mountain is more highly crystalline than number 204, which came from a point in the valley 600 feet below. But there are many reason for believing number 204 was in a valley of the erupted material and that this valley has not been eroded as much as has the top of Shepard mountain, therefore number 214 probably cooled farther below the surface than did number 204.

Now it is an interesting fact that all the granite exposures are on comparatively low ground, with porphyry hills near by; and also that generally there is good evidence of extensive erosion from the surfaces of the granite beds. Thus we find them along the valley of the St. Francois, the largest stream in the district; and along the lower portion of Stout's creek. The Graniteville quarries, it is true, are not located on a stream of any great size, but they are in a valley with high porphyry hills almost all around. Passing back from the streams we find that whenever granite is exposed it is a fine grained variety, and in

its general appearance resembles the porhpyries. In some places rocks were seen which, macroscopically, as much resembled the porphyries as the granites.

If we turn to the porphyries themselves we shall find, that those from the base of the hills are more coarse grained than those near the top. Number 268 is from the base of a hill more than 400 feet high. It is in structure half way between the granites and porphyries. All of the porphyrytes from number 273 to 280 are from quarries which are near the bases of the hills. They all have a very coarse grained microgranitic structure. Number 287, from about two miles west of the Silver Mines, is from the base of a hill 500 feet high. It has the pœcilitic structure very well developed, and is a very coarse grained porphyry.

In more than 220 hand specimens examined in the preparation of this article not a single one represents a coarse grained porphyry from the top of a hill, while many of them show that the rocks at the top of high hills are much more fine grained than those from the bases of the same. The transition from the coarsest microgranite into the finest grained felsophyre is absolutely without a break. The series from the coarse grained granite to the micro-granites is almost as complete.

No instance was seen in which this change could be traced from one extreme degree of crystallization into the other in the same rockmass. But this may be due to the insufficiency of the field-work done, or to the fact that a heavy covering of soil usually conceals the rocks over an area between the granites along the streams aud the porphyry hills farther back.

It is thought that the evidence now at hand is sufficient to warrant the suggestion, as a working hypothesis, that we have here an example of the gradual transition from a coarse grained granite into a very fine grained felsophyre; such transition in structure being due to the difference of physical conditions—heat and pressure—under which the various massess solidified, diffierences largely brought about by the varying depths at which different portions of the original magma existed.

The old classification of massive rocks based upon their age is at present almost entirely abandoned, but a short review of the work which has contributed to this result may not be amiss in this place.

The classification was based on the idea that there was a marked difference between the structure of pre-Tertiary rocks and those younger. It was believed, for example, that the granite and gabbros were of pre-Tertiary age, and that all rocks as young as the Tertiary which were similar to them in chemical composition differed from them materially in structure, being much less perfectly crystalline.

In 1874 Prof. J. W. Judd[1] published a long paper, on the secondary rocks of Scotland, in which he showed that the granites, and gabbros of Lyke, Mull and other points were of Tertiary age, and that they graded into the overlying volcanic rocks which were glassy, the degree of crystallization varying with the depth below the surface at which the rock mass solidified. In 1876 he published[2] a paper of similar import concerning the rocks of Shemnitz, Hungary.

In Feb., 1885, Messrs. Arnold Hague and J. P. Iddings[3] published their paper, *On the development of crystallization in the igneous rocks of Washoe, Nevada*, in which they showed that the structure of the rocks varied with the depth, and that the deep seated ones, previously called Archæan, were of the same age as those near the surface which had been called much younger. In the same year Prof. Alfred Steltzner[4] published his work entitled: "Beiträge zur Geologie und Palæontologie der Argentinische Republic," in which he describes four different localities in the Andes mountains near the boundary between Chili and the Argentine Republic that show gradual transitions from the holocrystalline rocks, such as granites and diorytes, into andesitic lavas, tuffs, and breccia. It should be noted that his field work was done from 1871, to 1874. In February, 1886, Prof. Judd[5] published a long paper reviewing those published by him in 1874 and 1876, and adding considerable evidence to the views therein expressed.

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[1] Quart. Jour. Geol. Soc., 1874, vol. 30, pp. 220-303.

[2] Quart. Jour. Geol. Soc., 1876, vol. 32, pp. 292-324.

[3] U. S. Geol. Survey, Bull. 17.

[4] Title as above, 1, Geologische Theil., pp. 198-213, Cassel und Berlin. The book was reviewed by Prof. G. H. Williams in Am. J. Sci,. vol. 33, pp. 315-316.

[5] Quart. Journ. Geol. Soc., vol. 42, pp. 49-97.

In April of the same year Signor B. Lotti[1] described certain Italian rocks which teach the same lesson. In 1887 Karl Dalmer[2] described the quartz trachytes and other rocks from Campiglia in which he finds additional evidence that crystallization depends principally upon the conditions of heat and pressure at the time of solidification, rather than upon the age of the rock magma.

(*d*) *Classification of the porphyries.*

In the classification of the porphyries it is customary to base the first general divisions on the mineral constituents of the rocks considered, and, a portion at least, of the subdivisions on the structure of the ground mass. In this way Rosenbusch divides the palæo-volcanic rocks into five general divisions, or families; the quartz-porphyries, the quartz-free-porphyries, the porphyrytes, the augite-porphyrytes, and the pickrite-porphyrytes. The first three of these families are well represented in Missouri, and the fourth very probably existed at one time, although at present, as before stated, the epidote is the only representative of the original bisilicate, whatever it may have been.

The quartz porphyries include representatives of three of the sub-divisions given by Rosenbusch. These three are: micro-granites, granophyres, and felsophyres, the rocks which originally were vitrophyres having been completely devitrified. The quartz-free porphyries can well be placed in a single sub-division, the orthophyres; the minor sub-divisions, such as augite orthophyre, biotite orthophyre, etc, have not been discovered, and probably do not exist.

The porphyrytes cover a very large area. The different varieties grade into each other so that division lines cannot easily be drawn between them. Some of them have quartz as an essential constitutent, and others do not. Some have an abundance of epidote, and others have none. Leaving out of consideration, the augite porphyrytes — and we have to do this, because we can say nothing about them with certainty — we may represent the classification of the whole of the palæo-volcanic surface rocks

[1] R. Com. Geol. D'Italio Boll., April, 1886, p. 73. Reviewed by Prof. J. D. Dana in Am. J. Sci., vol. 32, p. 239.

[2] Neues Jahrb, 1887. II Band, pp. 206-221.

of Missouri by the following scheme, the numbers used referring to typical specimens of each class.

Porphyries	Quartz-porphyry . .	Microgranite, 287, 347.
		Granophyre, 268, 410.
		Felsophyre, 204, 283.
	Quartz-free porphyry	Orthoclase, 213.
	Porphyryte	Epidote-free, 223.
		Epidote-bearing, 273.

C. Diabase and diabase porphyrytes.

Under this head are included all the dyke rocks of the district. It is thought they are sufficiently related to be considered, under one general head. The dykes themselves have already been described, so that the petrographic discriptions may at once be introduced.

(*a*) *Mineralogical composition.*

Mineralogically there is nothing new in these rocks. The most abundant mineral is plagioclase. Then follow augite, olivine, ilmenite with its decomposition product leucoxene, chlorite, iron-oxide — probably magnetite—hornblende, quartz, biotite, apatite, epidote, pyrite, calcite and serpentine. To this list of constituents glass must be added, since it forms an essential part of a few rocks.

The character and mode of occurrence of the greater portion of these constituents do not differ essentially from those often described by others, and consequently need only be mentioned in a general way. The ilmenite, leucoxene, and iron-oxide are present in all the rocks, and are quite uniformly scattered throughout the mass. The chlorite, of course, is a decomposition product, and is the most abundant in the weathered specimens. The biotite is scarce, but in a few specimens, particularly number 235, large individuals of it occur. Apatite, as usual, is scattered through all the rocks; epidote only occasionally occurs, and is probably always secondary. Pyrite is not often found, but a few of the porphyrytes have it scattered uniformly through the ground-mass. Calcite and serpentine are present only as secondary products.

(*b*) *Special description of minerals.*

Plagioclase. This mineral always occurs in the form of long,

slender crystals which generally show the twinning lamellæ very perfectly. A determination of its specific gravity in specimen 346, an olivine diabase, showed it to vary from 2.671 to 2.718. The same kind of a determination for number 415 gave a variation from 2.655 to 2.709. In this case the presence of a glass somewhat interfered with the separation, so that the results may not be exactly reliable. Quite a number of extinction angles were measured in other specimens by the Pumpelly-Lévy method with the following results:

Number 301 gave $38° + 37°$		Number 310 gave $38° + 36°$.
" 238 " $38° + 36°$.		

The results of these two investigations indicate that we have a lime-soda feldspar varying from andesin to bytownite, with possibly a little anorthite.

The size of the plagioclase individuals varies greatly. In the more coarse-grained rocks they can readily be seen macroscopically, but in some of the diabase porphyrytes they are not more than a tenth of a millimetre long. In a few cases the other constituents decrease until the rock is nearly all plagioclase. Numbers 349 and 365 are examples of this.

In the olivine diabase the feldspars are remarkably well preserved. Occasionally rifts across the crystals have their walls coated with a green decomposition product, but in many of the rocks this cannot be seen. In the uralite diabases, and those badly weathered, the feldspars are often clouded with decomposition products.

In number 235 orthoclase may replace a portion of the plagioclase, but the feldspars are so clouded one cannot say to a certainty.

Augite. This mineral generally occurs in allotriomorphous masses filling the spaces between the feldspars. In a few of the porphyritic rocks crystals with well formed outlines were observed. In the fine-grained varieties the augite is scattered throughout the groundmass.

In the olivine diabases it is unusually fresh, but in many of the others it is badly altered, sometimes to hornblende, and sometimes to chlorite and other products.

Olivine. This occurs in large quantities in nearly half the specimens examined. Occasionally it is sufficiently idiomorphic

to show the general outlines of the crystal and to have two or more planes well developed. Much more often, however, it is very irregular in shape, and not unfrequently is entirely surrounded by augite. Lines of fracture running through the crystals are very common. In the unweathered specimens the olivine is remarkably fresh, and is almost entirely colorless. As decomposition progresses the borders and walls of the fracture lines turn green, iron-oxide separates out — usually magnetite, but sometimes a blood red oxide — and serpentine is obtained as the end product, but the amount of this last is very small.

Hornblende. It is quite probable this mineral never occurs in the Missouri diabases as a primary constituent. Green, fibrous hornblende is found in many of the specimens, and brown hornblende in three or four of them. In the greater number of instances it exists under such conditions there can be no doubt concerning its secondary origin. Number 235 shows this quite well. It is a coarse-grained rock with some of the crystals fully one and a half centimetres long. The borders of nearly all these augites are completely changed to hornblende, either green or brown. It is not uncommon to find such a crystal with a rim of brown hornblende forming but one individual. Fig. 4, pl. i, represents a twin augite, with a green hornblende border, the portion on the smaller member of the twin being a single individual.

Number 370 also shows the change of augite to brown hornblende. Here we have a very fresh augite with few if any crystallographic outlines. In some individuals there are numerous little spots in which the change is complete. In other cases the altered parts are much larger, and in a few instances olivine crystals are entirely surrounded by the hornblende which is probably secondary.

The green hornblende of the uralite-diabase is usually quite fibrous. It is an interesting fact that in the specimens examined not a single olivine-diabase is uralitized, while very few diabases free from olivine were found in which uralite was not abundantly developed at the expense of the pyroxene.

Quartz. Few of the diabases contain quartz, but number 235 has a considerable amount of it which forms a beautiful micropegmatite with the feldspar. In other cases secondary quartz

is present, having resulted from the decomposition of some of the original.

In number 366, we have an interesting example of what seems to be primary quartz, existing in the form of porphyritic individuals. This rock, which came from sec. 10, T. 33. N. R. V. E., is a diabase porphyryte with a tolerably fine grained, almost holocrystalline groundmass, consisting essentialy of plagioclase and augite. It has numerous large, rounded, porphyritic feldspars, some of which are two centimetres in diameter. The porphyritic quartz is much smaller, the average diameter being about two millimetres. Fig. 5, a. pl. 1, represents one of these quartz-graines, and c, of the same figure is a secondary quartz.

Around these supposed primary quartz grains there is a border .08 mm wide which apparently is the result of a partial refusion of the quartz grain by the magma just before its final solidification. The border is composed almost entirely of little slender augite crystals a majority of which are radially arranged around the quartz. Some of these are as long as the border is wide, and some of them are much shorter. The inner portion of the border is decidedly green, but the color fades towards the outside, even in the same augite individual.

Mr. Charles E. Coates, graduate student in the chemical department of the Johns Hopkins University kindly made a silica determination of this rock for me which showed it to contain 53.4 per cent. SiO_2. It is by no means common to find free silica in a rock so basic as this. Its existence in such rocks which were once molten seems to be a chemical paradox. Recently, however, a number of similar occurrences have been reported, one of the most interesting of which is that described[1] by Mr. J. S. Diller of the U. S. G. S., In the basalt from "Cinder Cone" near Lassen peak, in California, he found quartz crystals whose presence could reasonably be accounted for only on the supposition that they were primary. An analysis of the basalt showed it to have 57.25 per cent. SiO_2, which makes it more acid than the Missouri diabase. Until more is learned concerning the effect of heat and pressure upon chemical affinity

[1] Am. Jr. Sci., vol. 33, p. 45, Jan., 1887.

one cannot well speculate regarding the possibility of quartz crystallizing out of a basic molten magma. We know that in the porphyries both quartz and feldspar are very often partially redissolved after being formed, showing that during the effusive period some cause made the chemical affinity differ from what it was at the time these crystals formed. For aught we now know it is possible that quartz would crystallize out of a deep seated, basic magma in a similar manner, and would be wholly or partially redissolved when brought near the surface.

Glass. About half the specimens examined contain an uncrystallized residue. The smaller dykes nearly all have it; and some of the larger ones as well. In fact the largest dyke in the whole district, the one at the place called the "Tin Mines" in sec. 30, T. 33. N. R. VI, E., has the most glass. The 50 inch dyke on the east side of the St. Francois also has a large amount of glass. In the majority of cases devitrification has been brought about by the development of small crystals of plagioclase so that the original glass has almost disappeared. Trichites and crystal skeletons of iron-oxide are very abundant. In some of the badly weathered diabase-porphyrytes the former existence of a glass base is shown by the presence of these crystal skeletons in the ground mass.

(*b*). *Structure of the diabases.*

The diabases vary in color from black with a waxy lustre, as in the case of those from the "Tin Mines," through steel gray, to light grey sometimes mottled. Some of them have a greenish tinge, and one, number 235, has so much pink feldspar mixed with large black augite crystals that it gives the whole rock a spotted pink and black color.

The texture of the diabases varies from coarse-grained with crystals two centimetres long to those so fine-grained that their macroscopic appearance is that of a homogeneous mass Number 284 and 289 perhaps are the extremes for fine texture. The microscope shows that number 284 is holocrystalline. This is quite unexpected, for it came from a six inch dyke in the porphyry. Number 289, from an eighteen inch dyke in granite, however, contains a large amount of glass.

The structure of some of the more coase-grained glass-bearing

rocks is quite interesting. Instead of appearing to be a glassy groundmass in which the crystals are imbedded it looks more as though the coarse crystals formed first and crowded the glass into the interstitial spaces, so that the structure is that of a typical diabase in which a portion of the augite is replaced by the glass. This particular type of structure is best illustrated in number 290, and in those from the "Tin Mines," numbers 359, 411, 414, and 415. Fig. 6, pl. 1 is taken from number 415, and shows a portion of the section as it appeared in the field of view when magnified 44 diameters. The occurrence of so much glass in such a coarse-grained rock is rather unusual.

It is also interesting to note that at the "Tin Mines" the amount of glass decreases as we descend below the surface. The dyke cuts through a big hill of porphyry fully 400 feet high. Years ago four different tunnels were driven into the hillside in a vain search for tin. The first of these is about 75 feet above the base of the hill; the others are higher up. Number 416, from this first tunnel, shows no glass, 415 has a small amount relatively, while 414 and 411 have a great deal of it. This locality was not visited by the writer, but from the character of the specimens received from Mr. Payne it would seem that we here have an excellent illustration of the crystallization of a molten magma being dependent upon the depth below the surface at which it solidifies.

The structure of the ordinary diabase and olivine diabase is so well known it is useless to give it here in detail.

(*c*). *Classification of the diabases.*

From what has already been given it will be seen that with reference to their mineralogical composition we have three grades, or classes of diabases, the quartz-bearing, the olivine-bearing, and those with neither of these minerals; also that the last division may be sub-divided into the uralitized diabases, and those in which the augite is not altered. With reference to the structure we also have a number of varieties. There are the holocrystalline, hypidiomorphic ones; the glass-bearing, coarse-grained, hypidiomorphic ones, and those with a true porphyritic structure. Only one porphyritic specimen was found which contained olivine, but further search would probably reveal

more, so this one must not be overlooked in the classification, although it is the only representative of the melaphyres. The following scheme represents the different types found, the numbers given being those of the hand specimens which are fair representatives of the several types. The classification is slightly different from that given by Rosenbusch in that all the dyke rocks are here placed under one general head for convenience, while he would place them under two.

- Diabase and diabase porphyryte
  - Quartz-bearing
    - Quartz-diabase, 235, 365.
  - Quartz and olivine free.
    - Holocrystalline
      - Non-uralitized — Wanting.
      - Uralitized .. — Uralite diabase, 236, 339.
    - Glassy
      - Non-uralitized—diabase porphyrytes, 290.
      - Uralitized—uralite-porphyryte, 388.
  - Olivine bearing
    - Holocrystalline — Olivine-diabase.
    - Glassy.......... — Melaphyre.

Summary.

1° The Missouri Archæan is interesting on account of its isolated position, and on account of the simple character of its rocks. 2°. The rocks may be divided into three general classes. A, Granites; B, Porphyries of different kinds; C, Dyke rocks which are diabase and diabase-porphyrytes. 3°. The granites are mainly granitites with a small amount of biotite, but they grade on the one hand into a quartz, feldspar granite —or granitell of some American geologists and on the other into a hornblende-bearing granitite. 4°. The feldspar enlargements of the granites probably resulted from a secondary growth, during the effusive period of idiomorphic crystals formed during the intertelluric stage. 5°. The idiomorphic quartz and feldspar crystals, the micropegmatite, and the granophyric structure show that the structure of the granites approaches the porphyritic, and the gradation of the one into the other is easily traced. 6°. The evidence of fumerole action at the Silver Mines consists in the alteration of the granite wall rock of the vein and the formation of topaz, wolframite, lepidolite, and fluorite. 7°. The

porphyries have a mineralogical composition which is almost identical with that of the granites. 8°. The occurrence of the rare manganese epidote, piedmontite, was noticed in three different specimens, and probably it has a much wider range. 9°. The structure of the porphyries varies from what was originally a vitropyre with the flow structure well developed, through the different grades of microfelsyte, granophyre, and micro-granite into the fine-grained granites. 10°. The poryhyries have a structure, not described by others, for which the name pæcilitic is suggested. 11°. The dykes seem to be of Archæan age, but possibly a few of them are younger. Nearly all of them trend from northeast to southwest, or approximately parallel to the Ozark hills. 12°. Four general kinds of dyke rocks occur, the quartz-diabase, the uralite-diabase, the olivine-diabase, and the diabase-porphyryte. 13°. The quartz-diabase is interesting on account of what seems to be primary, porphyritic quartz in so basic a rock. 14°. The olivine-diabase is a very beautiful rock which is unusually well preserved. 15°. The amount of glass in the big dyke at the "Tin Mines" decreases as we descend from the surface, so that specimens taken from the lowest tunnel show none.

ON SOME INVESTIGATIONS REGARDING THE CONDITION OF THE INTERIOR OF THE EARTH.

PROF. E. W. CLAYPOLE, AKRON, O.

The condition of the interior of the earth is perhaps the most difficult problem with which geologists are now grappling. Progress is slow, necessarily slow. All work must from the nature of the case be done at arm's length or more so to speak. Inaccessible as are the depths of the sea we can reach them by the use of an immensely elongated slender finger—the sounding-wire with its grapnel and dredge. These implements actually bring within our grasp some small specimens of the material of which the bottom consists so that we are able to handle and examine it in the laboratory.

But we are totally unable thus to reach and explore the in-

terior of the earth. All the mines and wells and bore-holes that have been sunk are but so many punctures in the skin revealing nothing of the great central mass below. No auger has ever fathomed more than a single one of the four thousand miles that separate us from the centre. And the data thus obtained from this single mile are too slender, the material is too scanty to warrant wholesale induction regarding the greater inaccessible residue of the sphere. Direct examination fails and we are therefore driven to employ indirect methods — to infer from feeble manifestations at the surface the nature and the intensity of the energies at work below — to extend cautiously but immensely the results of petty experiments in our laboratories until they match in magnitude the vast operations in the great subterranean laboratory of nature — and finally to deduce from the known properties of matter its necessary or probable behaviour in unknown and unattainable conditions. All this is working under immense difficulties and at enormous disadvantages; and progress toward the solution of this interesting problem is proportionately slow.

And when in addition to all this we reflect that in order to deal with the subject a man should possess knowledge of a high order in mathematics and physics, and ability to use readily the most powerful engines at the command of these two sciences not less than those methods more strictly geological, we can understand why so few enter the field and why the results of their labors are so small and so uncertain.

Yet there is progress. From year to year some new fact is made known on evidence that commands general assent. Some new inference is deduced that deserves examination. Some new possibility is suggested that promises to reward investigation. Through these three stages all our knowledge regarding the condition of the earth's central mass is destined by the nature of the case to pass.

Not very long ago it was an accepted doctrine that the earth was composed of a hot and liquid internal sphere surrounded by a solid shell of comparatively small thickness. This doctrine may yet be recognized in some of our popular semigeological literature. But it has passed into oblivion as a tenet in geology,

being found totally inadequate to explain the phenomena as they appear at the surface.

As this opinion waned there rose in its place another directly opposed to it. Ushered in under the shadow of great names in the world of science it taught us to believe that the globe was solid from core to crust. We were told that all our geological theories must be reconstructed on the basis of a solid globe. The authority of Thomson, of Hopkins and of Pratt secured for this new doctrine a respectful hearing and a wide acceptance. It was a not unnatural reaction from the opposite extreme which had preceded it. It afforded for a while great hope of a final solution of the problem. But it has been tried and found wanting. Like its predecessor it has failed to explain the phenomena.

No other extreme being possible most of the later theories have been modifications or combinations of these two, with qualifying additions intended to explain special difficulties or fill inconvenient gaps.

Without going into detail, which would be foreign to the purpose of this paper, it will suffice to say that most of the more recent theories involve the presence of a layer of imperfectly liquid matter between a solid nucleus and a solid crust. This layer is by some supposed to be continuous and by others to be divided into lakelets of greater or less extent. Both these views are held by geologists well qualified to form and well entitled to express an opinion. Each is intended to account for certain phenomena which have proved difficulties in the way of the adoption of the other.

This viscous layer is not only a result of a compromise between two opposing theories but is also a result of a compromise between the two great solidfying forces of pressure and cold. It appears to be a necessary result of the evolution of the terrestrial sphere. Looking back to the time when the earth existed as a molten globe it is evident that the constant radiation of heat from its surface into space must have steadily though slowly, cooled the outer layer. This as fast as it grew cool and perhaps solid sank into the heated mass in consequence of its greater density. There it was remelted but at the expense of the internal store of heat. This process continued until the

whole globe had so far cooled down that its original fluidity was lost and it became viscid or slaggy. The sinking of the cooled crust then ceased because convection-currents could no longer travel between the centre and the circumference. Free motion between one part of the sphere and another was henceforth impossible and all further cooling must take place by the slower process of radiation from the surface and conduction from the interior. Even by this means some further refrigeration must have occurred in the long interval that has since elapsed so that the centre itself is now rather lower in temperature than it was when solidification took place.

On this view then the interior of the earth consists of a mass of matter intensely hot but less so than some writers have asserted. As already mentioned there is abundant reason to believe that it is solid. But it is under enormous pressure and this pressure has the effect of raising its temperature of solidification or in other words of its freezing-point. It is consequently solid at a temperature at which it could not remain solid were the pressure removed. That is to say, a portion of the central mass if suddenly transferred to the surface would instantly become liquid merely from relief of pressure.

On this view the internal temperature must increase from the surface downward to the very centre. But the inference that this increase continues at the same rate as that which we find near the surface would be very hasty. As was remarked at the outset, the greatest depth yet reached by an auger is infinitesimal compared with the 4000 miles that separate us from the centre, and to assume therefore that the law of increase which it reveals will be found to hold good at great depths would be not only illogical but, in view of the considerations above stated regarding the condition of the central mass, it would be exceedingly improbable. It is more in consonance with them to believe that the *rate* of increase of temperature downward will be found to steadily diminish until it becomes insignificant, and for practical purposes from that point down to the centre the temperature may be considered constant.

The interior of the earth on this view then is a sphere of matter whose nature is unknown but which is kept solid solely by the pressure of the mass above it. It is therefore always on

the point of fusion and in so unstable a physical condition that the relief of the pressure at any point would cause its instant liquefaction. This fact must be borne in mind in all reasonings on the problem.

As the central mass is kept solid by pressure so the superficial layers are solidified by cold. They have radiated off into space their original heat and being unable on account of the bad conducting quality of the matter to obtain a sufficient supply to replace it from below, they have become as cold as is consistent with slow conduction from the heated core and with powerful solar radiation.

The existence of the viscous layer already mentioned is then an almost unavoidable deduction from the history and actual condition of the earth. So far as we can judge from the analogy of experiments on a small scale the rise of temperature downward is much more rapid than the rise of the freezing or solidifying-point resulting from increased pressure. It seems therefore a necessary inference that at some depth there must be a layer where the temperature is so high as to cause semi-fluidity in spite of pressure. But the *rate* of increase of temperature as above shown becomes less and less until it almost disappears. The solidifying effect of pressure therefore, which is subject to no such decrease downward, but which rises to the very centre at an increasing rate in consequence of greater density of the materials, must eventually overtake and surpass the liquefying effect of higher temperature and produce solidity in spite of the heat. The interval between the levels of supremacy of these two contending forces, heat and pressure, is therefore the viscous layer where neither is supreme.

(To be continued.)

MONTICULIPORA, A CORAL AND NOT A POLYZOON.

BY JOSEPH F. JAMES, M. S.,

Professor of Botany and Geology in Miami University.

In a late paper upon the "Monticuliporoid corals of the Cincinnati group,"[1] undertaken by Mr. U. P. James and the present

[1] Published in the Journal of the Cincinnati Society of Natural History, vols. X and XI.

writer, the various genera proposed from time to time for different species, were all arranged under one family, the *Monticuliporidæ*, Nicholson. This family includes two genera, with three sub-genera. These are (1) *Monticulipora*, with the three sub-genera *Dekayia*, *Constellaria* and *Fistulipora*, and (2) *Ceramopora*. In the paper in question all these forms were regarded as corals. They have been, except *Ceramopora*, generally regarded as corals, but they have been placed by some writers, principal among whom is Mr. E. O. Ulrich, in the class Polyzoa, or as he calls it, Bryozoa.[1] Dr. H. A. Nicholson and most other workers on the other hand, retain the *Monticuliporidæ* in the corals. The question of the position of the family being thus a disputed one, it will be the endeavor in the present paper to settle the matter, and in order to do this it will be necessary to examine the features of the two classes and see upon what grounds the reference of the *Monticuliporidæ* to the Polyzoa is advocated.

The great sub-kingdom, CŒLENTERATA, inclndes many diversified forms both fossil and recent, the various genera ranging in time from the Palæozoic to the present. There have been generally recognized two classes, although some members of these have at times changed places. As at present understood these two classes are *Hydrozoa* and *Anthozoa*. The greater part of the first of these are medusæ, marine animals difficult of preservation and therefore of study; while the fresh water *Hydra* is an example of another part. So few of these have ever been preserved in a fossil state that so far as palæontology is concerned they may be regarded as almost non-existent. One fossil group, that of graptolites, has been referred here, but Dr. Lankester does not regard these forms as at all closely allied to the Hydrozoa proper. We are, however, not here concerned with this question.

The *Anthozoa* include the larger number of these forms known as true corals, and we shall have with this at present

[1] The former of these two terms, viz.: *Polyzoa*, has four years precedence over the latter. J. V. Thompson applied the term *Polyzoa* in 1830 ("Geol. Researches and Memoirs, V"), while Ehrenberg used *Bryozoa* for the same forms in 1834, ("Abhand, der k. Akad. der Natur. zu Berlin.") See Encyclopedia Britannica, 9th edition under *Polyzoa*.

mainly to deal. The class *Anthozoa* has been divided into three great orders, namely, *Zoantharia*, *Rugosa*, and *Alcyonaria*. The *Zoantharia* again have been divided into three groups, one (*Malacodermata*) including the sea-anemones, in which there is either no skeleton at all, or else a pseudo-skeleton made up of scattered spiculæ; a second, (*sclerobasica*) in which the colonies are more or less branched and fleshy; and a third (*sclerodermata*) in which a true calcareous corallum is always developed. It is this last group of the three with which we now have to deal, as it is only here that the forms are preserved in a fossil state in any numbers.

The *scelrodermata*, then, have been divided by the great authorities, Edwards and Haime into four sections, namely, *Aporosa*, *Perforata*, *Tabulata*, and *Tubulosa*. In the *Aporosa* are found mainly living genera. The corallum is made up of a great number of tubes which are divided longitudinally by well developed septa; while cross partitions, tabulæ, are rarely found. *Favistella* is probably an example of this group. In the *Perforata* the septa may be well or may be only slightly developed, and in some cases the tubuli are crossed by tabulæ while in others they are open. The walls are very generally perforated. This group contains many fossil genera, such as *Protaræa* and probably the *Favositidæ*. The third group, the *Tabulata*, originally formed to contain those corals in which septa are scarcely developed at all and tabulæ are well developed, seems such a mixed collection of forms that it has been proposed to break it up and distribute the genera elsewhere, or else greatly restrict its limits. Of the genera formerly included in it, some have been transferred to Hydrozoa (*Millepora* for example, though this has also been placed in the order *Alcyonaria*), some have gone to *Perforata* (*e. g. Favositidæ*), while others have been transferred to the order *Alcyonaria* (*e. g. Monticuliporidæ* and *Helioporidæ*). Of these last two families we shall have more to say directly. Lastly the *Tubulosa* constitute a small group to which belongs *Aulopora* and possibly *Stomatopora*. These present some affinities to the Polyzoa, and may have to be transferred there. These then are the groups of *Zoantharia sclerodermata*. Let us turn now to the second order, or

The *Rugosa*. The members of this, like the previous group, are possessed of a stony corallum, and present generally both tabulæ and septa. The order is divided into four families, *Stauridæ*, *Cyathaxonidæ*, *Cyathophyllidæ*, and *Cystiphyllidæ*. To the third of these belong *Zaphrentis* and *Streptelasma*, but as none of the group seem related to the *Monticuliporidæ* we pass on to the third and last order.

The *Alcyonaria*. Of the five families into which this order is divided, but one presents any affinities to the monticuliporoids. This is the *Helioporidæ* Mosely. This author has examined *Heliopora* in a living state and describes it as having a well developed, stony corallum, composed of corallites of two kinds. Both kinds are tubular; the larger ones are crossed by well developed tabulæ, and the walls are folded in such a way as to give rise to a variable number of septa. The smaller, (interstitial?) tubes are destitute of septa, but have numerous tabulæ. The living parts of the corallum occupy only the spaces in the corallites above the uppermost septum. Several extinct genera, *Heliobites*, *Plasmopora*, &c., present similar features to *Heliopora* and are referred to this family. Finally we find in the *Monticuliporidæ* several features which show it to be closely related to the *Helioporidæ*. In the sub-genera *Dekayia*, *Constellaria* and *Fistulipora* the large tubes are often nearly surrounded by smaller ones. In *Monticulipora* proper, these interstitial corallites vary in number in different species, being sometimes very few, and again very numerous. Septa seem to be absent in both kinds of tubes, a point of difference from *Helioporidæ*, but tabulæ are generally well developed in both kinds, though there is great variation in this respect. In certain species of *Monticulipora* it is found that the walls of the corallites are more or less inflected, and it may be that these are the possible remains of former septa. From this examination it is clear that the *Monticuliporidæ* are in many features similar to the *Helioporidæ*; and it would seem the best plan to place the families side by side, as members of the *Alcyonaria*.

If we turn now to the Polyzoa we find here also a mixed assemblage of forms. The class is divided into three sections, all of which are in general terms characterized upon the living animal. The first two sections contain three genera, all of

which are living and one of which forms a membranous, branching tube (*Rhabdopleura*) similar in general appearance to those of certain species of *Stomatopora*, but all the tubes are connected. The third section includes the greater number of the genera of the class, and is divided into three orders. The first of these contains five genera. One of them, *Cristatella*, is remarkable for having a locomotive zoarium, but it resembles in no respect any monticuliporoid. *Alcyonella*, however, forms massive cœnœcia made up of several hundred individuals. The second order, GYMNOLÆMA, is divided into three sub-orders (by Busk), according to the shape of the zoœcia, and the nature of the margin of the mouth when the polypide is retracted. The *Cyclostema* "have long tubular zoœcia, often of large size and calcified, placed side by side in cylindrical bundles or in other definite grouping; the mouth of the zoœcium is circular and devoid of processes." (Ency. Brit., 9th Ed., xix, p. 437.) Most of the genera of this group are fossil. It includes *Stomatopora*, *Fenestella*, &c. The second order, CTENOSTOMA, has species with usually a soft zoœcium, but the third, CHILOSTOMA, is the largest and most varied. "The zoœcia are horny or calcified; their orifices can be closed by a projecting lip in the form of an operculum. * * * The surface of the zoœcium is frequently sculptured, and its orifice is provided with processes and spines." (Ibid, p. 437.) It includes *Retepora*, *Flustrina*, *Ptilodictya*, and others.

Now although the Polyzoa include forms of so diverse an aspect, we find little in their appearance to justify placing the monticuliporoids with them. And while it may be regarded as an impossibility to settle definitely and without dispute the position of the monticuliporoids without having the living animal, it may be considered that all their features point to an alliance with the Coelenterates rather than with the Molluscoidea.

Let us now turn to the paper of Mr. Ulrich in which he states his reasons for calling the group of monticuliporoids, Bryozoa, [Polyzoa,] and see upon what grounds this is advocated. Without going into the details we appeal to the summary of his views as given on pages 144-147 of volume v, of the Journal of the Cincinnati Society of Natural History. The genus *Heteropora* is taken as the type of the Polyzoa. (Is it not rather an

aberrant member of the class?) As a resemblance it is stated that both in *Heteropora* and in certain ramose species of *Monticulipora*, the corallum is "composed of slender fasciculate tubes, which are nearly vertical in the axial region of the branches, and then curve outward more or less abruptly to reach the surface." (p. 144-5.) I would point out, however, that in the sub-genus *Fistulipora*, we have the corallites in one ramose form (*venusta*) springing from a "wrinkled, dermatic crust" direct to the outer surface without bending. In other species, both discoid and frondose of the proper genus, *Monticulipora*, the corallites spring upward from a germinal plate also without bending (*e. g. frondosa*, *whiteavesi*, *petasiformis*, &c.,) so that this difference between the axial and peripheral region does not always hold good. Neither is it by any means universal, if, in deed, the rule, in Polyzoa.

Second, the dimorphic condition of the corallum in both *Heteropora* and *Monticulipora* is made a point of resemblance; as is also the presence of tabulæ in the large tubes, the smaller ones in *Heteropora* lacking these. But it should also be remembered that there are certain species of *Monticulipora* (*e. g. filiosa*, *irregularis*, *discoidea*, *briarea*, *delicatula*, *septosa*, *kentuckiensis*, *wortheni* etc.,) which have no interestitial cells: others which have a few, and still others in which they are numerous. So this resemblance can not hold. It is also to be noted that in the various species tabulæ may be few or numerous; and it has already been pointed out that these in themselves cannot be considered as of very great value in classification.

Third; in regard to the structure of the walls of the corallites it is stated that the discovery of a few mural pores in *one portion* of one specimen of a single species of *Monticulipora* is in accord with the condition of *Heteropora*, while, on the other hand, some species of the latter genus are without these pores. It is sufficient to note that in the Favositidæ and other members of the Perforata of Zoantharia, these pores are very numerous, and there can be no denial of the fact that the *Monticuliporidæ* are eminently imperforate.

Fourth; the possession of certain radiating spines in *Heteropora* and their absence in *Monticulipora* is commented upon, but Mr. Ulrich does not attach any weight to their absence in

Monticulipora, "since if it were a character of real importance, such as the 'septa' of *Cœlenterata* it would be developed in all the species, which our present knowledge of these forms justifies us in saying, is not the case." (Jour. C. S. N. H. v, p. 147.) But the septa are *not* developed in all forms of Cœlenterata (*e. g. Favositidæ*) and there are certain species of *Monticuliporidæ* in which there are found projections from the wall of the cell into the cavity, (*ortoni* and *septosa* for example,) which may or may not have been in the nature of septa. And further it should be remembered that in *Heliopora*, certainly a true coral, the septa are but poorly developed, these being produced merely by the foldings of the walls of the corallites as may well have been the case with *M. ortoni* and others.

Fifth; spiniform tubuli are stated to be developed in the majority of *Monticuliporidæ* as they are also in *Heteropora.* But these are *not* found in *briarea*, *septosa* and possibly others, for in the descriptions of many species no mention is made of them, and they are few to numerous in many species.

Sixth, and lastly, in weighing the points of resemblance between *Heteropora* and *Monticulipora*, Mr. Ulrich says, (Ibid, p. 146): (1) The colony is composed of two sets of tubes: (so also is the corallum of *Heliolites* and other undoubted polyps); (2) both have their tubes crossed by diaphragms; (it is so also in *Heliolites*, *Favosites*, etc.); (3) in certain types of *Monticulipora* the interstitial tubes are in no way structurally different from the proper ones: (but so is it also in *Heliolites*); while (4) in relation to the mural pores these are present or absent in the Aporosa (corals), and so can scarcely be considered as a sufficient character to depend upon.

From all these things we fail to see why it would not be just as wise a course, if indeed not a wiser one, to place the *Monticuliporidæ* close to the *Helioporidæ*, as to remove them to the Polyzoa. Individually, and we are not alone in the belief, we believe that the *Monticuliporidæ* constitute a family closely allied to the *Helioporidæ*, and that they belong to the order *Alcyonaria* of the class *Anthozoa* of the CŒLENTERATA.

NOTE.—We are indebted to the article on *Corals* in the *Encyclopedia Britannica*, written by Dr. H. A. Nicholson, and to that of *Polyzoa*, by Prof. Lankester, in the same work, for much of the information relating to the features of these two groups embodied in the above article.—J. F. J.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

RECENT PUBLICATIONS.

1. State and government reports.

Report on a part of northern Alberta, and portions of adjacent districts of Assiniboia and Saskatchewan. By J. B. Tyrrell. Part E. of the annual report of the Geol. and Nat. Hist. Sur., of Canada, for 1886; pp. 176; two maps; Montreal.

Penn. Geol. Surv.; annual report, 1886. Part III. *Anthracite coal region.* By Frank A. Hill. Illustrated with a frontispiece map of coal fields; a heliotype page plate; and three folded maps, with an atlas of seven sheets.

2. Proceedings of scientific societies.

Proc. Canad. Inst. April, 1888; and annual report of the same, 1886-87. *Toronto.* The latter contains the report of David Boyle, Curator, on archæological work in 1887.

Bulletin of the N. Y. state museum of Natural History, No. 3. March, 1888. Building stone in the state of New York. By *John C. Smock.*

3. Papers in scientific journals.

In *Am. Jour. Sci.*, May. Three formations of the middle Atlantic slope. *W. J. McGee.* (with plates vi and vii). On some peculiarly spotted rocks from Pigeon Point, Minnesota. *W. S. Bayley.* The Taconic system of Emmons, and the use of the name Taconic in geologic nomenclature. *Chas. D. Walcott.* The terminal moraines in North Germany. *Prof. R. D. Salisbury.*

4. Excerpts and individual publications.

Illustrations of the fauna of the St. John group. No. iv. Part I. Description of a new species of Paradoxides (P. regina). Part II. The smaller trilobites with eyes (Ptycoparidæ and Ellipsocephalidæ). By G. F. Matthew, M. A. *Trans. Roy. Soc., Canada.* Presented May 25, 1887.

A preliminary notice of a new genus of Silurian fishes. By G. F. Matthew. Read Oct. 5, 1886. Bulletin of the Nat. Hist. Soc.

American geological classification and nomenclature. By Jules Marcou, pp. 75. Cambridge, Mass.

5. Foreign publications.

Lakis kratere og ivastromme, at Ammund Holland; Universitetsprogram for 2nd. semester, 1885. Kristiana.

Reports of geological explorations during 1885 with maps and sections. Sir. James Hector, director. Wellington, New Zealand.

Same for 1886-87.

Index to reports of the geological survey of New Zealand from 1866 to 1885 inclusive.

Notice nécrologique sur M. A E. Béguyer de Chancourtois; par M. Edmond Fuchs. [Extrait des Annales des mines. Mai-Juin, 1887]. *Paris.*

Note sur la constitution des gites de phosphate de chaux, et sur les conditions spéciales de gisement de ceux du nord de la France. par M. Edmonds Fuchs. Assoc. Franc. l'avanc. d. Sciences, 1887.

Jahresbericht des Vereins für Erdkunde zu Stettin, 1887.

Anthozoen und Bryozoen des obern mittelrussischen Kohlenkalks; von A. Stuckenberg; mit 4 Tafeln, 1888; also, Die Fauna des untern Devon am west-Abhange des Urals, von Th. Tschernyschew, mit 9 Tafeln, 1885; also, Bibliothèque géologique de la Russie, 1886. *Comite geologique, St. Petersburg.*

Shell-growth in cephalopoda (Siphonopoda.) By F. A. BATHER, of the British Museum. (Ann. and Mag. Nat. Hist; April, 1888).

CORRESPONDENCE.

Hayden Memorial Geological Fund. Mrs. Emma W. Hayden has given to the Academy of Natural Sciences of Philadelphia in trust the sum of $2500 to be known as the Hayden Memorial Geological Fund, in commemoration of her husband, the late Prof. Ferdinand V. Hayden, LL. D. According to the terms of the trust a bronze medal and the balance of the interest arising from the fund are to be awarded annually for the best publication, exploration, discovery or research in the sciences of geology and palæontology, or in such particular branches thereof as may be designated. The award and all matters connected therewith are to be determined by a committee to be selected in an appropriate manner by the Academy. The recognition is not to be confined to American naturalists.

Academy of Natural Sciences of Philadelphia.

Philadelphia, May 8, 1888.

The proposed geological society. Geologists will recall the fact of the appointment of a committee of their number at the meeting of the A. A. A. S. in 1881 to consider the advisability of forming an *American Geological Society.* This committee sent out circulars asking for opinions, and received 126 answers to their inquiries, all but two of which expressed a belief in the expediency of organizing such a society. These facts were reported at Montreal in 1882. It was there voted expedient to establish a geological magazine. A proposed constitution for a society was presented, discussed and laid upon the table for future consideration. At the adjourned meeting in 1883 at Minneapolis the questions of the magazine and society were further consider. Little was accomplished beyond

the appointment of a committee to confer with the Mineralogical and Geological section of the *Philadelphia Academy of Natural Sciences*. For various reasons no meeting was called to discuss the subject at Philadelphia. Since then regret has been expressed by some who were at first opposed to the project that the effort had not been pressed. At the New York meeting of the International Congress Committee (A. A. A. S.), August, 1887, the following resolution was passed: "That the American Committee of the International Congress will approve of a call for the meeting of an American Geological Congress, whose object shall be the discussion of important geological questions."

The chief objection to the establishment of an American Geological Society has been the fear that its existence would impair interest and attendance at the meetings of the American Association for the Advancement of Science. But if the new society could be made identical with Section E, retaining the officers chosen at the meetings of the A. A. A. S., and having the power to assemble at other times during the year, adopting necessary regulations for the extra sessions, it would seem as if the geologists might obtain all the advantages of a special organization.

The chairman and secretary of the above named committee of American geologists would therefore call upon all American geologists to assemble with them at Cleveland, Ohio, at 3 P. M., of Tuesday, August 14th, the day before the next session of the A. A. A. S., and if deemed expedient, organize a society subject to the following limitations:

1. The members of the society shall be also members of the A. A. A. S.
2. The president and secretary of the new society shall be the gentlemen elected to these offices by the A. A. A. S.
3. It will be recommended to Section E. at its formal session to offer an amendment to the constitution of the A. A. A. S. that Section E may be allowed to hold meetings at such time and place as they may desire, independently of the other sections, subject to their own regulations.

[Signed,] N. H. WINCHELL, Chairman,
C. H. HITCHCOCK, Secretary.

PERSONAL AND SCIENTIFIC NEWS.

THE GEOLOGICAL LABORATORY OF BUCHTEL COLLEGE, Akron, O., has recently acquired a lapidary's lathe and fittings of the latest make and finish, with slitting disc and bort slicer, laps, grindstone and necessary polishing powders, complete, as used in the British Museum. Some difficulty was experienced at the port of entry (N. Y.) as the importing agents without advice paid the duty, and were unable to procure its refundment, the department of the interior being apparently unaware

of the extent to which these instruments have lately been introduced for the study of some branches of geology and consequently being in doubt if the lathe in question could be regarded as a scientific instrument entitled to free entry for college use. As the final decision may be of interest to others it is here reprinted. The lathe was manufactured by the firm of Cotton & Johnson, Gerard St., Soho, London, W., and the total value including all charges of freight and entry was about $120.

Lapidary's Machine.—The Treasury Department has granted the application of Messrs. Davis, Turner, and Co., for the free entry of a lapidary's machine recently imported at New York for the use of Buchtel College, Akron, Ohio. It was shown that machinery of the kind long used by lapidaries is now indispensable in the study of geology and lithology for use in the preparation of sections for examination under microscope. The department therefore decides that such machines can be admitted free under the provision of the free list for "philosophical and scientific apparatus specially imported in good faith for use of any institution established for educational purposes." — *U. S. Government Advertiser, March, 15, 1888.*

DR. ALLEYNE NICHOLSON maintains in the *Geological Magazine* for March, in reply to Mr. James Thomson, the constant occurrence of mural pores in all favositoid corals, and that failure to find them must be caused by peculiar mineralization, unfortunate slicing or, to use a mild euphuism, "want of knowledge."

DR. LYDDEKER NOTES THE OCCURRENCE of fossil bones in the upper Eocene of England undistinguishable thus far from those of Iguana and proving therefore the former existence of this now exclusively American genus in Europe.

Discussing further a number of specimens in the British Museum we find that several which have hitherto passed under different names all belong to *Placosaurus*, and moreover that this genus was closely allied to the Anguidæ though possessing well developed limbs. It therefore apparently furnishes a creature of snake-like aspect and affinity with the legs of a lizard, and may be a direct ancestor of our present boas and pythons in which all the limbs are rudimentary and scarcely visible outside; a structure which is matched on a small scale by the little blindworm of English copses, *Anguis fragilis.*

Dr. Lyddeker advocates the retention of the term *Palæophidæ* to denote a family of large marine (?) serpents whose remains are found in the London and Bracklesham Tertiary clays, and which are generally regarded as also nearly allied to the existing pythons.

PROF. E. W. CLAYPOLE, ONE OF THE EDITORS of this magazine, will sail for England on June 7th, by the SS. "State of Georgia," of the State line. His family will accompany him and they will remain in Europe till September.

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